Vol. 19 APRIL 1946 No. 4

Instruments

THE MAGAZINE OF Measurement and Control

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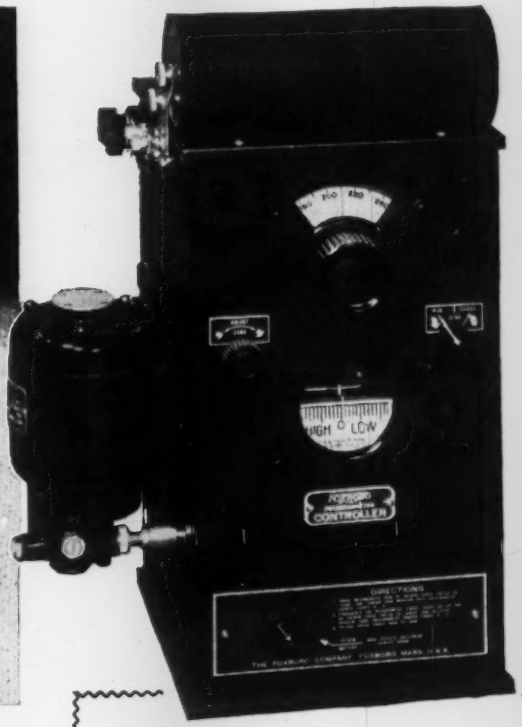

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Instruments
THE MAGAZINE OF Measurement and Control

Vol. 19 April 1946 No. 4

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Automaticity and Instrument Men's Jobs

IT is not unusual to receive letters from non-subscribers (or even new subscribers who are not yet full-time or full-fledged instrument men) opposing the views expressed on this page. It was a shock, however, to receive an inquiry from an experienced instrument service man expressing his fear that he himself would fall a victim of "technological unemployment." Several times a year during the last fourteen years we have used this page to refute the "technological unemployment" agitation and we have not only explained how *Automaticity Makes Jobs* but even dared to formulate a new "law"—the law of technological displacement (which we summarized in the word *upgrading*).

So this letter came as a shock. The writer is not a 'fraidy-cat or a weakling; he displays ability in marshalling his data, his inferences and his conclusions. He is employed in a large modern plant devoted to the *mass* production of *high-quality* electrical and electronic components—which means 100% inspection for various characteristics: many workers (mostly girls) connecting or placing the parts one by one in testers and reading the deflection-type electrical indicating instruments. Our friend's job is to check, service and re-calibrate *these* instruments (a full-time job).

The progressive management has announced that it will gradually introduce automatic inspection devices. Most of the jobs held by girls will cease to exist. Our friend infers that there will be "no more meters" (no more instruments). He concludes that his job, too, will cease to exist.

Wrong inference; wrong conclusion.

The management being progressive, it will require that product quality be safeguarded even better by the automatic inspection equipments than it is by the girls who now take readings. Every electrical characteristic will have to be measured even more accurately, by means of *measuring elements*, one or more of which will therefore have to be incorporated into every inspection machine. Functionally, these measuring elements will correspond to the indicating instruments now being read by the girls on the inspection lines. The maintenance and servicing of these "movements" will be even more important because the products will be passing through the machines (whether by hand feed or by conveyor) at a much faster rate.

And that is not all: most of the measuring elements will sound audible signals, or flash red and green lights, or actuate relays opening the acceptance and rejection chutes. Thus, our friend's servicing job will be more important.

Our friend will be upgraded by Automaticity.

What of the girls? They too will be upgraded—few of them directly and immediately but all of them eventually by the advance in the American standard of living which always results from every increase in productivity and reduction in repetitive human drudgery. —MFB

What's Cooking *Now*?

OUR February 1945 editorial entitled "What's Cooking?" predicted "thousands upon thousands of new things for your postwar plant, laboratory, aircraft, vehicles, or other instrument application." This prediction was safely based on a sampling of "kitchens" where new instruments were being designed and produced. Some revolutionary developments were still on the secret list, but—

"... I'm happy to testify that the censorship has not been blindly rigid ... radically new developments have been reported in this magazine. ... On the whole, therefore, you need not look forward to a 400-page issue of *Instruments* a month or two following victory. I don't know how quickly the censors will lift restrictions and how quickly the 1000-odd instrument companies will prepare their descriptions. ... Of course I'm making plans to give you a first-rate reportorial job in this coming period of disclosures but personally I believe that this period will last SIX MONTHS OR MORE owing to the needs of converting special war instruments to the needs of America's postwar civilian industrial structure."

Now it looks as if the period of disclosures will last much longer than six months and will consist of two phases, one already waning, the other beginning:

(1) Most of the really revolutionary developments such as radar instruments, isotope-separating instruments, etc., have been disclosed. Naturally, their total number is relatively small (just how small depends on where one draws a dividing line between "revolutionary" and merely "new and useful"). This is the first phase now tapering down.

(2) The second phase consists of disclosures (mostly commercial announcements) by instrument companies. This phase began shortly after VJ Day but it seems to be gathering impetus now. This month's "New Instruments" department sets a new record with eighty items.

This period of disclosures of war developments, however, is not "what's cooking now" but it is only the serving of what *was* cooking.

What's cooking *now* is activity in the research lab of every instrument company as it learns that its competitors were not all asleep. Thus, there may be a third phase of the period of disclosures, beginning in 1948 ... perhaps before. And it will all be for your benefit!

But wait not for those dream robots of tomorrow: today's improved models are sufficiently superior to yesterday's for all your immediate purposes. —MFB

TOGETHER with an increasing volume of "New Instruments" items, there is an even greater volume of "Instrument Society News" items. Since the paper shortage is still acute, the items in these two departments are again being printed in relatively small type—THIS size and face, which we call *relatively* small because although it would not do for a four-page article to be read at one sitting, it is no strain at all in separate self-contained items.

Refinery Instrumentation *par Excellence*

IT frequently happens that word of outstanding installations of special automatic controllers seeps by the grapevine before any pictures and descriptions are released. A little bird recently told us that the engineering firm of E. B. Badger & Sons Co., and the Sun Oil Company, had jointly achieved a miracle of instrumentation in automatizing a Houdry fixed-bed catalytic cracking unit. We may, or we may not, be able to print a technical article about it in the not-too-distant future; but right now we are happy to have received the striking photo reproduced on this month's cover, together with the following brief but excellent description:

"Centralized and automatic control in the highest refinement is illustrated by this partial view of the control panels of a Houdry Fixed Bed Catalytic Cracking Unit. The large dial in the lower left is the indicator of the electrically-actuated cycle timer which controls to a split-second the operation of the motor-operated valves governing the sequence of oil flow, purging, air flow and purging in the cycles of the respective catalyst chambers or cases. The diagram, upper center, indicates by means of colored lights the positions of the major valves on the catalytic cases, giving the operator an instantaneous visual check of the sequence of operations."

THE KEINATH RECORDER

EDITOR'S NOTE. Above title substituted at last moment, without asking Dr. Keinath's permission, for title he wanted: "The New Sweep Balance Recorder Plotting Automatically 48 Readings From 48 Transmitters Into 48 Curves Within 7.5 Seconds."

Reasons: (1) 1/6 length of former title. (2) Higher speeds than 48/7.5 are possible. (3) Precedents justify using inventor's name.* (4) In "sweep balance," word "balance" suggests usual "balancing" (really REbalancing) operation which always comes to a full stop: no such pause in sweeping-past-the-null-point idea. (5) This idea is but one of several Keinath inventions that go to make his new system; any technically-correct descriptive title would be too long. (6) Seldom was a great innovation so largely one brain's from inception through years of development. (7) Best reason: it's high time! Since 1910 Dr. Keinath has been inventing and making new instruments, from big flowmeters to miniature ammeters, most of them called "Siemens & Halske" because he headed that firm's huge instrument works until 1937 when he settled in this country (with which he had fallen in love on a previous visit for the World Power Conference). This being his most important disclosure since he became a U.S. citizen, we feel we would have betrayed the American spirit of fitness if we had failed to make this the occasion for starting a chain reaction of esteem. —M. F. Béhar

*Brief examples: Yale lock, Hooke joint, Root pump, Braun tube, Crookes tube, Gramme ring, Froude brake, Broca tube, Bourdon tube, Addis tube, Pitot tube, Geissler tube, Dewar flask, Claisen flask, Fuller house, Franklin stove, Gatling gun, Erard harp, Volta pile, Jacquard loom, Kelvin bridge, Bailey bridge, Ledoux bell, Ayrton shunt, Weston cell, Eppley cell, Corliss valve, Korting jet, Stillson wrench, Nicol prism, Tesla coil, Freeman weir, Bouchet crank, Heywood clutch, Argand lamp, Pirani gage, Rillieux pan, Zeleny key, Bessemer steel, Ingersoll watch, etc.

By GEORGE KEINATH, Great American Industries, Inc., Meriden, Conn.

IN recent years there has been a trend toward automatic testing and at the same time there has been an increasing demand for plotting measurements automatically into diagrams. The number of measuring circuits assigned to one recorder has far exceeded old standards. Instruments have been built to take care of as many as 150 circuits, for test problems where a thousand or more transmitters were used on one process, aircraft, etc. For such multiple-recording problems the recording speed is of the greatest importance. The highest speed obtained so far with direct-recording methods is slower than one transmitter per second, so that with 50 transmitters one recording cycle takes about one minute. This is an intolerably long time when testing modern airplanes, etc., because the unrecorded changes which occur during each one-minute interval make it impossible to attain the claimed static accuracies of 0.1% or 0.2%. To meet modern testing requirements, therefore, it is desirable to increase the speed of modern multi-recorders five-fold, ten-fold, or more.

Another disadvantage of present multi-recording methods is that they do not give individual diagrams: all measurements are "point-printed" in the same way as conventional multi-color recorders work, but with two differences: (1) only one color is used and (2) between coördinated points from one transmitter there are 50 to 150 points from other transmitters. Such diagrams do not present a "picture" of the test. To produce such a "picture," it is necessary to take the readings from the multi-point recorder chart and to trace the diagrams by hand, which labor takes at least ten times the actual recording time.

Multi-recording problems may be divided in three groups:

(1) *The supervision of a great number of machines or processes, all of the same kind* (e.g., temperature-controlled furnaces) *or connected with a certain production group* (e.g., motor speeds, currents, rolling pressure, temperatures, production length in a steel mill). One case of this kind has been published where in each group in a rolling mill 65 strip-chart recorders for currents, speeds, etc., were used—all with synchronized charts.[1] Although the initial cost of the recorders and the running expenses for charts, operators, etc., may be justified for the purpose, the mere space required for so many recorders represents a considerable expense. Furthermore, with so many recorders, it is impossible to get a picture of the performance while production is going on: the study of basketfuls of paper is undertaken later on, only when such a study is deemed necessary. If recorders capable of simultaneously producing 24 diagrams of different magnitudes were available, only a few such recorders would be needed and space and servicing would be minimized.

(2) *The testing of structures and complicated machinery.*[2] Conventional multi-point recorders generally are not fast enough and cannot be used for magnitudes of a different nature (e.g., temperature, flow, pressure, torque, energy) at the same time. Separate instruments have to be used and their charts synchronized. For this reason, test data are generally read and noted by several observers and finally plotted into diagrams. For 1000 such readings the element of human error is present 2000 times: once when reading and once when plotting each point. Many essential details get lost if, in order to save time and work, the readings are made at too-long time intervals. A partial breakdown in a high-voltage bushing[3] or in a mechanical structure showing up with a little discontinuity in an otherwise smooth curve of power factor versus time, or strain versus stress, will be mistaken for a slow increase of dielectric losses with temperature or of creep with time or stress, if readings are made at long time intervals and plotted by hand. For such tests a full-automatic high-speed recorder, plotting the diagrams immediately on the chart so that they are visible during the test, appears to be highly desirable.

(3) *"X-Y Recorders."* Another modern requirement is to trace automatically one or more variables as function of a further variable, which is not time. This requirement was emphasized in 1940 in a strongly-worded discussion[4] from which the following is quoted:

> "... These recorders may be roughly defined as those which produce '*x-y*' diagrams ... function is to plot automatically the mutual values of two measurables neither of which is time.
>
> "Oldest example in engineering is the engine 'indicator' which produces a pressure-volume diagram. In physical testing the autographic stress-strain recorder produces a load-deformation curve. In chemistry the polarograph produces the current-voltage curve for the Heyrovsky method. In acoustics automatic analyzers plot decibels *vs.* frequency. In electric power transmission engineering the Allen and Gross Equipment produces frequency *vs.* current peak charts for locating faults. Most spectacular of all, perhaps, is Professor Ralph Müller's spectral-distribution color analyzer which produces a wave-length *vs.* relative energy curve in 1/20 second.
>
> "In these six examples we have twelve different measuring elements and eleven different methods of displacing a pencil, a pen, a drum, a light spot or a cathode-ray spot.
>
> " ... Our special purpose is to call attention to the possibilities opened up by the development of thoroughly reliable relay, follow-up and servomotor devices ... successfully employed in self-balancing bridges and potentiometers, in telemetering systems and in automatic-control systems. ... Why not use one of these mechanisms to position the chart drum according to the value of '*x*' while another measuring-and-operating system positions the pen according to the value of '*y*'?"

For this category of recorders the author proposed the name "*X-Y* Record

(1) John W. Esterline, "Graphic Routes to Greater Profits" (book). Esterline Angus Co., Indianapolis, 1938. Pages 142-143.

(2) W. T. Dickinson, "Flight Testing Equipment for Large Aircraft," *SAE Journal*, Vol. 51, April 1943, pages 139-147.

(3) George Keinath, *Archiv fuer Technisches Messen* (ATM) August 1934, V 339-11, Figs. 9 and 16.
Ibid, Nov. 1935, V 339-13, Figs. 4 to 8.
Ibid, Dec. 1935, V 339-14, Figs. 13 and 14.

(4) M. F. Béhar, "Coördinatographs," *Instruments*, Vol. 13, May 1940, page 113

ers" and proposed also to distinguish between "true" and "pseudo" *X-Y* Recorders.[5] The second group covers recorders in which the measured magnitude follows the stylus movements whereas for true *X-Y* recorders the stylus follows the magnitude. In the simplest case of such "pseudo" *X-Y* recorders both increase in proportion to time. With "true" *X-Y* recorders the stylus movements in both directions follow only the variations of the respective magnitudes. Old examples of such "true" *X-Y* recorders are the mechanical stress-strain recorders and the engine indicators. A hitherto unfulfilled dream of testing engineers is an electrical stress-strain recorder capable of tracing as many as (say) 48 diagrams from 48 strain gages at the same time.

To meet these three requirements of modern testing technique, a new high-speed recording method has been designed by the author, for which he suggests the name Sweep-balance System.

Brief Historical Survey[6,7,8]

A short excursion into the history of electrical recording instruments would appear to be in order. The first ones were of the direct-recording type with a pen attached to the end of the pointer of an ammeter, voltmeter or wattmeter, the instrument necessarily having high torque and, consequently, relatively high energy consumption. Many types and varieties of such recorders have been built, especially in Europe where most of these recorders use a gear mechanism or other means to obtain rectilinear coördinates. For heavy current circuits, where enough energy is always available, such direct-recording instruments have proved fully satisfactory. For other applications, however, especially in connection with thermocouples, no direct recording is possible and it is necessary to supply auxiliary energy to the recorder. The simplest solution is the *chopper bar recorder*, with the pointer being momentarily pressed against the chart surface at regular intervals of 5 to 15 seconds. This type of intermittent recorder originated in Europe and has been manufactured and used there until today for temperature measurements almost exclusively, despite its disadvantage of being not a null-method but a deflection-method instrument influenced by variations in line resistance and generally characterized by low sensitivity and low accuracy.

The use of the *null method* and of auxiliary energy has two objects: first, to provide high torque so that the friction of mechanisms used to obtain rectilinear diagrams may easily be overcome; second, to make possible the use of wide charts and to increase at the same time the accuracy and sensitivity of the instrument.

The balance can be effected mechanically or electrically.

The balance point can also be approached in two ways: (1) "step-by-step" or (2) in a "continuous-balance" movement (if the new sweep-balance method is left out for the time being). It may surprise the reader to learn that continuous-balance recorders celebrate this year the fiftieth anniversary of their basic idea: the Callendar Recorder, manufactured by the Cambridge Instrument Company in London in the last years of the past century, used a bridge or potentiometer circuit with a ribbon-suspended moving-coil galvanometer actuating a relay motor to rebalance the system. Very shortly later (still in the late nineties) the Olivetti Company in Milan (Italy) developed for heavy current measurements a motor-operated continuous-balance recorder with a wide chart and rectilinear coördinates—a design which, of course modernized,[9] is still manufactured today. Later (1905) followed the Westinghouse continuous-balance recorder with a relay motor arrangement.

(1) Step-by-step Recorders: The Callendar continuous-balance recorder,[6,7,8] as desirable as it appeared, was not satisfactory for industrial application because of its delicate relay contacts on a suspended-moving-coil galvanometer. The greatest progress in high-sensitivity null-balance recorders was made for many years when Morris E. Leeds on October 23, 1909, filed U.S. Patent No. 965,824, published July 26, 1910. This invention uses "periodically operated means for transmitting power to a movable member through mechanical means." Best known under Leeds & Northrup's trade name "Micromax," this step-by-step recorder has become the prototype of temperature recorders all over the world. A rugged suspended-coil galvanometer is used for the null detector and, with a mechanism operating at regular time intervals of about 1.5 seconds, the slide-wire contact is adjusted in steps of decreasing width. The total time for such a balancing operation in a step-by-step recorder is between 5 and 30 seconds, generally around 10 seconds. This method of recording is used in most of the modern temperature recorders, combining high accuracy with high reliability. Twelve (or even more) circuits are connected to one recorder, so that one full recording cycle takes, according to the number of transmitters, from one to three minutes. Colors and numbers identify the transmitters, but such identification is imperfect when there are more than six diagrams of the same shape and with little phase displacement.

(2) Continuous-balance Recorders: The first relay-motor-operated recorders of this type (such as the Callendar and others mentioned above) were slow and of poor sensitivity. The relay contacts in particular were the source of incessant trouble. The advent of electronic amplifiers and the perfection of phase-sensitive a-c. motors made it possible to develop a-c. continuous-balance recorders (e.g., for a-c. resistance thermometers) which were very satisfactory in regard to speed and accuracy. Almost ten years ago the author had developed the "Numo" recorder for the automatic recording of power factor and capacitance changes during high-voltage tests.[10] A watt-hour meter motor was used at that time, nevertheless very satisfactory speed was obtained: only two seconds to travel across a chart 5" wide. The most modern recorders of this type use much more powerful shaded-pole induction motors, with which travel times of one second for a 10" chart are obtained. This system is almost ideal for a-c. measurements; it uses no contacts at all; there is no movement as long as there is no change of the measured magnitude.[11,12]

The application of the continuous-balance recorder to d-c. problems, especially for recording temperatures with thermocouples as the primary elements, brought new problems, first of all the development of a reliable d-c. amplifier for a range of 10 millivolts or less. With every increase of recording speed the problems of hunting and damping increased correspondingly. However, modern engineering overcame these difficulties, and there are now also several working solutions of the high-speed direct-current continuous-balance recording problem.[13,14,15,16]

(5) George Keinath, "Extensive Use of New 'X-Y' Recorders Foreseen," *Instruments*, Vol. 15, Jan. 1942, page 20.

(6) George Keinath, "Die Technik Elektrischer Messgeraete" (book) R. Oldenbourg, Munich and Berlin 1928, first volume, third edition, pages 360-440.

(7) Perry F. Borden and M. F. Béhar, "Electrical Recording Instruments," *Instruments*, Vol. 7, Dec. 1934, pages 257-265; Vol. 8, Jan. 1935, pages 7-14; Feb. 1935, pages 34-44.

(8) C. V. Drysdale and A. C. Jolley, "Electrical Measuring Instruments" (book) Ernest Benn Ltd., London 1924, first volume, pages 171-212.

(9) Bruno Usigli, "Moderni Istrumenti Elettrici di Misura Registratori e loro Impiego," *L'Elettrotecnica*, Vol. 16, May 15, 1929.

(10) George Keinath, "An Automatic A-c. Potentiometer and Its Application to the Non-destructive Testing of Insulating Material" ("Numo" recorder), *Transactions Supplement Electrical Engineering*, Vol. 58, 1939, pages 887-893.

(11) D. M. Nielsen, "Strain Gages" (Foxboro "Dynalog" recorder), *Electronics*, Dec. 1943, pages 106-111, 192, 194.

(12) P. S. Dickey and A. J. Hornfeck, "Electronic Type Instruments for Industrial Processes" (Bailey "Pyrotron" recorder), *Transactions ASME*, July 1945, pages 393-398.

(13) W. Mikelson and H. W. Bousman, "Rapid Recording A-c. Bridge," Transactions Electrical Engineering, Vol. 59, 1940, pages 628-631.

(14) C. Owen Fairchild and V. Lawrence Parsegian, "Photoelectrically-balanced Recording Potentiometer" (Tagliabue "Celectray" recorder), *Review of Scientific Instruments*, Vol. 9, Dec. 1938, pages 422-425.

(15) M. E. Moore, "Automatic Temperature Recorder Control System," *Transactions ASME*, Nov. 1943, pages 809-815.

(16) T. R. Harrison, W. P. Wills and F. W. Side, "A Self-balancing Potentiometer" (Brown "ElectroniK" recorder) *Electronic Industries*, Vol. 2, May 1943, pages 68-69, 153-155, 157.

Travel times of less than one second for the 10" chart have been obtained also for these sensitive d-c. recorders. Using photoelectric amplifiers, a recorder with a full range of only one microvolt d-c. has been built.[17] This type of super-sensitive recorder is used for the automatic analysis of spectrograms. For high-speed recording of only one magnitude versus time, the continuous-balance recorder system, as far as performance is concerned, is fully satisfactory for most problems.

Multiple Recording. For multiple recording up to six or eight circuits, the continuous-balance method may be used with the conventional arrangement of different colors used in step-by-step recorders. With a total time of 1.5 seconds for balancing, printing and switching, for eight circuits the cycle length is 12 seconds, compared with at least 60 seconds for step-by-step methods.

Identification of more than eight or ten transmitters by different colors is impracticable and therefore, as already done for multi-color recorders, a number is printed on the side of the mark, using only one color for up to 144 transmitters. Such a high number is divided in "banks" of twenty, which are numbered or marked separately. The chart moves with a constant speed of 120 inches per hour and in the Leeds & Northrup Flight Analyzer[17] one complete cycle of 140 thermocouple points and seven bank marks is printed on an 8" length of a 10" wide chart in four minutes. Reducing the number of transmitters from 140 to only 48, would reduce the cycle time from 240 seconds to 78 seconds. By arranging the thermocouples in such a way that all nearby-equal temperatures are measured successively, the time can be reduced still further, so that we have about 60 seconds for 48 transmitters. We are now using the fastest recording system available for single-condition recording, but this is still too slow for many problems of multi-recording. To meet the requirements of modern testing, a new method of high-speed multi-recording had to be devised.

Operating Principle of the Sweep-Balance Method

The sweep-balance principle is best explained with the aid of Fig. 1 which shows an *oscillating potentiometer* with sweep-balance recording—a design not contemplated for production at the present time but which offers the clearest picture of the principle. It would be used for strip-chart recorders, but there are other solutions possible, for example continuous movement of three styluses on a ribbon traveling over two wheels, only one stylus in operation at one time. Another solution is the use of a helix on a drum, as the Hogan-Alden facsimile recorders.

The simplest electric circuit is shown, with resistance thermometers, fed from a d-c. battery. Likewise the simplest null relay is shown: a permanent-magnet moving coil relay. (Other relays are: moving magnet and fixed coil; electrodynamic with moving coil and fixed coil; and electronic relays.) Finally, in the arrangement shown, the chart assume that the total duration of the sweep over the full scale, from 0 to 100°C., takes exactly 1000 milliseconds, and that the temperature of the thermometer is 28°C. At the moment we touch the left end of the slide wire, a current of say 3 milliamperes flows through the diagonal and the relay coil, pressing the relay arm against contact *a*. As we travel along the slide wire, the current decreases, in first approximation in proportion to the traveled length, until it becomes zero at the

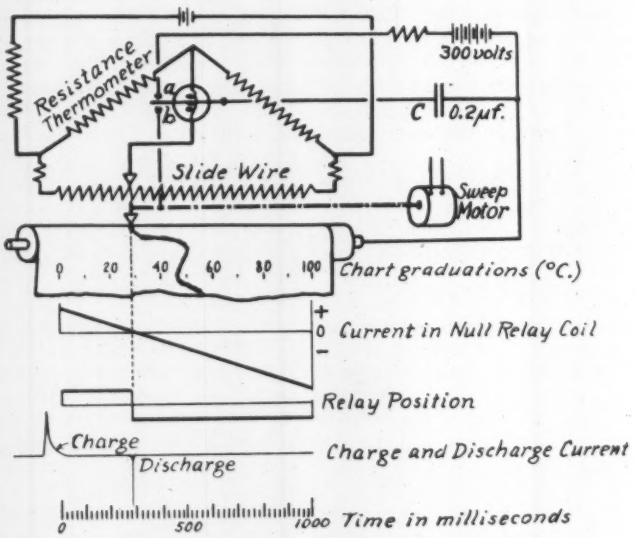


Fig. 1. Operating principle of a sweep-balance recorder, shown for: resistance thermometer with d-c. supply; moving-coil null relay; strip chart with oscillating stylus movement.

is moved with time as usual, by a clock or a synchronous motor.

A linear "potentiometer" resistor is used, which has the same length as the chart is wide, say ten inches. Of course a rotary resistor can be used just as well by using mechanical gear.

The slide-wire contact and the stylus are held by one block which is moved by the "sweep motor" over the full length of the scale and the full range of the potentiometer.

Before this movement is started, a capacitor (about 0.2 microfarad) is charged from a source of some 300 volts, by closing contact *a* of the relay, or in any other way so that the capacitor is ready for discharge at the moment the travel across the scale starts. We have to assign a certain fraction (5% or 10%) of the duration of the sweep cycle to do this charging. There must always be some space between the diagrams and therefore we cannot use full 360° rotation of a rotary resistor—only 270°, 300°, or at the most 330°. A series resistor limits the initial charging current, but without unduly slowing up the rate of charge. If we have a sweep cycle of 100 milliseconds duration, we have to complete the charge in less than 5 or 10 milliseconds.

Now, with the capacitor charged, we are ready for the "sweep." Let us division 28. At this moment the contact arm opens contact *a* and instantly moves to contact *b*, closing the discharge circuit and making a mark on the paper as explained below. With further travel of the slide-wire contact, the arm is more pressed against contact *b*, the current reversing and increasing until the end of the scale. At the end, the slider going off the resistor causes the current to drop to zero, thereby opening contact *b* (no current flowing) and (with a connection not shown) the capacitor is charged before the slider again starts at the left end of the resistor.

The sweep-balance recorders built so far use only the discharge effect at the balance point. The time between start and balance point may be used for integrating devices such as horsepower-hour meters to be described some time later.

This marking may be done for an indicating instrument by using a light flash not longer than 0.1% of the sweep cycle on a circular scale, either for indicating directly or for photographing the position of the contact on the scale. For recording directly on a chart we use the capacitor discharge to mark voltage-sensitive paper with a stylus moved in synchronism with the balancing element. It is clear that in this way, with a high-speed electromagnetic or electronic null relay, all the pitfalls of continuous-balance recording

(17) Gabrielle Asset, "A Photoelectric Galvanometer Amplifier." *Electronics*, Vol. 18, Feb. 1945, pages 126-129.

(18) I. Melville Stein and A. J. Williams, Jr., "High-speed Multiple-point Recording of Thermocouple Temperatures During Flight Tests of Planes." *Instruments*, Vol. 17, Jan. 1944, pages 26-28.

(19) L. R. Miller, "Electronic Wattmeter." *Electronics*, Vol. 18, Nov. 1945, pages 133-135.

are avoided; there is no problem of damping, nor a problem of hunting. Relay and discharge have to work in a time not longer than 0.1% of the sweep time, which means 1 millisecond for one sweep per second. In our electronic age, when we use much more powerful capacitor discharges of 1000 watt-seconds and more for high-speed flash photography for flash durations of one microsecond, the control of a discharge energy of some 0.01 watt-second to be dissipated in 100 microseconds is no problem.

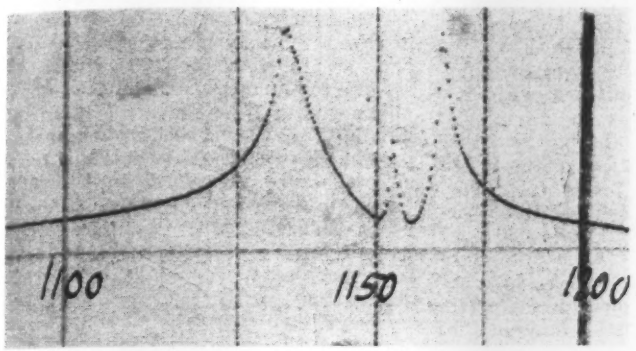


Fig. 2. Frequency spectrogram of a damaged steel bell shown as an example of a pseudo *X*-*Y*-recorder, threshold principle, moving-iron relay, applied for production testing. Total recording time 10 minutes for three specimens at the same time. (Illustration shows in actual size a 3⅜" wide portion of the chart, whose total width is 10".)

The sweep-balance system can be applied in different ways, for indicating, recording, integrating and differentiating instruments.

There may be an electrical or a mechanical sweep balance, when the input energy (mechanical or electrical) is balanced by the counter-force of the relay. A variety of sweep balance recorders has been called "Threshhold Recorders" and it has to be used when compensation of the *X*-magnitude by a known magnitude of the same type of current (d.c. or constant-frequency a.c.) is not possible. One application of the threshold recorder is the recording of frequency spectrograms of vibration of parts or structures for the purpose of testing for flaws.[20] Fig. 2 shows a diagram of amplitude versus frequency, made with a threshold recorder on a steel bell. While a good bell showed a diagram with only one peak, a saw cut at the periphery would considerably change the picture from one to two or even three peaks, at the same time showing increased damping.

Sweep-balance recording in principle means intermittent recording and only if the points come close enough together to merge can the diagram be a continuous line. The time which we allow for the complete diagram and the rate of change of the recorded magnitude are the two factors which determine how near we come to the ideal closed line.

The frequency of the sweeps or the total recording time have to be set in such a way that a certain minimum (e.g. 300 points) is used to trace one diagram. However, it is of course better to have 600, 1200 or even more points for a diagram base length of 5" or 10" so that for a straight line we have from 75 to 250 points per inch. If the magnitude under test changes rapidly, we get much greater distances between the recorded balance points. If, for instance, there is a change of the maximum sweep magnitude of 10% within one second, corresponding to 1" deflection change on the chart, we will need a sweep speed of ten per second to keep the ten points 0.1" apart in this section of the diagram. If, however, the recorder is used for getting only one diagram per day, and we have a total length of 10" for the base, with only one sweep per minute we will get 1440 points per diagram or 144 per inch on the horizontal.

(20) George Keinath, U. S. patent reissue 22,293, Dec. 29, 1942; application filed July 12, 1941.

The Elements of Sweep-Balance Recorders

It would take a book to cover all design possibilities of the sweep-balance method. So far, only a few recorders have been built and only these will be described. Before describing complete recorders, it is in order to describe the elements of the system.

(1) Stylus Positioning

Sweep-balance recorders generally operate with a continuous movement of stylus relative to paper, or vice versa. The stylus is positioned by time, or, if we have an *X*-*Y* Recorder, by the *X*-magnitude. As an example: the *X*-axis, parallel to the drum, may represent temperature, the *Y*-axis a resistance change. Only for one of the two magnitudes can the sweep method be used, the other magnitude has to position the stylus. To do this, a straight-line potentiometer resistor may be used with a continuous balance system which combines high speed with high torque. The selection of the circuit depends on the intensity and nature of the signal from the transmitter, circuits operating with line frequency being preferable.

(2) Sweep Circuit

In the simplest arrangement (Fig. 3) a fixed circular voltage-dividing resistor is arranged coaxially with the drum, the contact arm rotating with the drum, flashing the capacitor discharge at the instant the balance point is passed. The frequency of the maximum permissible sweep speed depends on the time lag of all the elements used, especially the type of relay and the constants of the discharge circuit. In our laboratory recorders, up to ten sweeps per second have worked well as far as the electrical side of the problem is concerned and even this is not the limit. However, since mechanical problems are involved, we do not go beyond two revolutions per second, corresponding to a paper speed of 16" per second. For the endless strip-chart recorder the maximum paper speed, for the time being, has been fixed at 4" per second. These figures are very far away from the speeds used and recommended for facsimile recorders: 160" per second and even more.

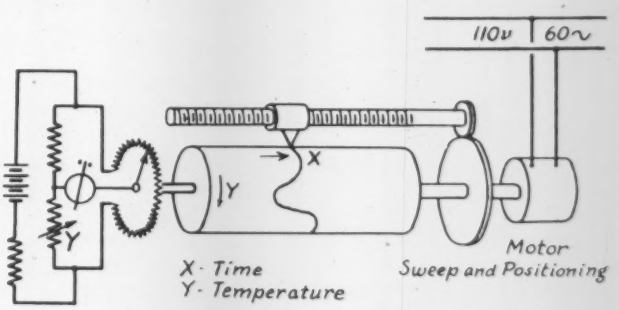


Fig. 3. Sweep-balance recorder with time positioning of the stylus. Example shown: recording temperature vs. time with a d-c. resistance thermometer.

With one revolution of the drum we may cover one or several circuits (transmitters), as will be explained later.

(3) Null Relays and Maximum Relays

For null methods of recording, the sweep balance principle calls for a relay which at the reversal of the current or voltage moves from the charging position of the capacitor control to the discharge position with a minimum of current change in the relay and a minimum of time. Any type of relay may be used—an electromagnetic relay or an electronic relay or any other kind, e.g. a hydraulic relay. The simplest arrangement (at least to explain the operation of the recorder) offers itself for d.c. when enough energy is available to operate directly a permanent-magnet moving-coil null relay, which is the ideal electromagnetic relay as far as sensitivity and contact pressure for a given energy input are concerned. The relay operates under very favorable conditions: the charge contact is opened only after the charge is completed (which may take as little time as 1% of the total sweep period) and no current flows and no voltage difference exists between relay arm and contact. In the other

position of the relay arm, with a travel of less than one-half angular degree, the discharge circuit is closed and the current surge from the capacitor is released. The contact arm displacement is very small: between 0.1 and 0.3 mm. The time of transition from one contact to the other contact depends on the sensitivity of the relay, and how much it is overloaded away from the balance point. If, for instance, we have a moving-coil relay which, if the pointer could move freely and were not blocked by a contact, would give, with ten microamperes, a deflection of 100 degrees within one second, we could expect (as a rough approximation) to cover one degree deflection within 1/100 of a second. In fact, the problem is very complicated, the time to travel over the first degree deflection depending on many factors and, first of all, not being linear with time. Now, if we have a sweep circuit which applies a maximum current of not 10 but 100 microamperes to the relay coil, then, at the reversal of the current, the relay arm will travel much faster over the gap between the contacts: about ten times as fast, or in 1/1000 of a second. Experiments have shown that this assumption is basically correct, that it is possible to travel over the air gap of such a moving-coil relay with an accuracy of better than 0.5 millisecond.

When the energy of the potentiometer circuit is not sufficient (does not deliver enough energy to the relay) and especially when we work with a.c. and hence do not have such sensitive relays, amplifiers have to be added. With null method recording, the degree of amplification is without effect on the measurement, but not with a "threshold recorder" which is a deflection method, because the amplified current is balanced by a counterforce in the relay. For low-frequency as well as high-frequency a.c., we need phase sensitive relays, which may be electromagnetic, electrodynamic, or electronic.

For high frequency of the transmitter signal, which means here 1000 or 2000 cps, electronic relays have proved to be the best practical solution, combining high sensitivity (after amplification of the diagonal current) and high speed. The design of such electronic relay circuits offers some interesting problems and will be discussed in a later publication. For the description of the recording principle the symbols of the electromagnetic moving coil relay have been used throughout for simplicity.

(4) Recording Surface.

In principle, any type of "voltage-sensitive" paper may be used for sweep-balance recorders if the capacitor discharge is "shaped" accordingly. Recording with real sparks requires at least 3000 to 5000 volts (as with the old spark recorders built forty years ago). Ordinary tissue paper as well as wax paper could be used, but the recording accuracy without direct contact of the pen or stylus with the paper would not be satisfactory. Presently-built sweep-balance recorders use "Teledeltos" paper, as in Western Union facsimile recorders, which is also in principle a "breakdown paper," consisting of a black base with metallized back, coated with a white cover of a metal oxide, which breaks down under voltages of 100 volts or more applied to a metal stylus sliding direct on the paper. When the coating is destroyed by the current, the black base is clearly visible. The time lag is extremely small: in facsimile recording it has been shown that 10,000-cycle a.c. can be recorded with individual dots. Two kinds of "Teledeltos" paper are available, one with a light gray surface with low resistance, and one with an almost white surface with high resistance (5000 to 20,000 ohms, depending on the voltage and paper speed) for which peak voltages up to 500 volts are necessary for paper speeds up to 80" per second.

Also suitable for sweep balance recorders are the true electrolytic papers which require a certain humidity of the salt-impregnated paper surface and where a real electrolysis takes place between the electrolyte in the paper and the metal of the stylus, the latter being slowly eaten up and needing periodical replacement. This type of paper, used in the Hogan and Alden facsimile recorders, gives black lines on white, semi-transparent paper. Such lines can be copied, which is not possible (except with a photographic process) with "Teledeltos" paper. On the other hand the necessary high moisture of the paper offers some inconvenience. Both papers are reasonably priced, although of course more expensive than ordinary recording paper. "Teledeltos" paper, being not changed by humidity or high temperature, makes it possible to place recorders in unattended places (bridges, dams) where no regular service is available, or on board cargo ships and freight cars. The wet paper may eventually bring the possibility of using the sweep balance principle for recording in different colors.

(5) Discharge Circuit

Many variations are possible. Using a capacitor discharge, voltage, capacitance, resistance in the charge and discharge circuit, as well as the discharge energy may be varied. An energy of about 10 milliwattseconds per discharge has been found satisfactory with "Teledeltos" paper. A potential around 300 volts is used for ordinary work; higher voltages for ultra-high recording speeds.

It is not necessary to release a capacitor discharge: and d-c. or a-c. source can be discharged to the paper, either when one contact is opened or when the other contact is closed, or even while the contact arm moves from one contact to the other. For applications where no power supply line is available, it is possible to use a 6-volt dry battery to charge a high-capacitance unit, discharging it over a transformer to get the necessary high voltage to mark the paper. Even pocket batteries are capable of delivering the requisite energy in intervals of one minute for many months.

(21) Milton Alden, "Facsimile in the Police and Emergency Communications Field," *The Municipal Signal Engineer*, July-Aug. 1945. Reprint obtainable from Alden Products Co., Brockton, Mass.

Accuracy and Sensitivity of Sweep-Balance Recorders

Although the sweep-balance system is new for measuring purposes, it utilizes design elements of facsimile recorders for its operation and the accomplishments of these devices give an indication of the speed and accuracy possibilities which can be obtained from sweep-balance recorders. In the published information on three different types of facsimile recorders (one radio[22], two over wires) we find the following data:

Diagram size of facsimile recorders: about 8" × 8".
Linear recording speed: from 24" to 80" per second (and higher).
Accuracy of recording, as shown on straight lines, including synchronization: ±0.004".

This gives for all facsimile recorders a time accuracy of within 0.1 millisecond, including errors of start-stop-synchronization. In sweep-balance recorders (other than radio flight recorders utilizing this principle) the recording stylus is directly connected to the balancing element and therefore all synchronizing errors which may appear in telefacsimile recorders are eliminated.

Disregarding here, in discussing accuracy, the moving-coil relay, and assuming the use of an electronic null relay without any inertia lag, it appears that we can expect from sweep-balance recorders the same 0.1-millisecond time accuracy as for facsimile recorders in the same way as we talk about damping errors and hunting errors and friction errors of conventional recorders of the continuous-balance type, excluding all calibration errors and inaccuracies of resistors and capacitors. In order to play perfectly safe, it shall be assumed that the recording error is twice as high as with facsimile recorders and amounts to 0.2 millisecond. Let us see what this means in instrument accuracy:

For a sweep cycle of one second or more, the recording error of 0.2 millisecond is not more than 0.02% of the full scale. Even with a speed of ten drum revolutions per second the error does not exceed 0.2%, which is still negligible as against "electrical" calibration errors. Even with 33 milliseconds per sweep (which would corre-

(22) W. S. Halstead and J. A. Craig, "The Finch Facsimile System," presented before Washington Section, Institute of Radio Engineers. Reprint obtainable from Finch Telecommunications, Inc., 10 E. 40th St., New York 16, N. Y.

spond to 30 sweeps per second, or 10 sweeps per second with three voltage dividers each covering 120 angular degrees) the error caused by the recording principle would not exceed 0.6% of full scale.

Generally speaking, the same actual accuracies can be obtained with sweep-balance recorders as with "precision-grade recorders" utilizing other systems, provided that the adjustment of the electrical components is of the same accuracy. With increasing recording speed the theoretical accuracy will be lower. Small diagrams will give less percentual accuracy than large diagrams with the same linear speed. If the full scale has to be obtained with an exceptionally low range and risk of an error of 10% of the full scale. For this reason, for any multi-recorder, it is wise to increase speed and dynamic accuracy even at the expense of static accuracy.

"Step sensitivity"

For an instrument with linear scale the sensitivity may well be indicated by the signal (generally millivolts) for the full scale. In this respect the sweep-balance recorder is basically not different from others. A full-scale range of 10 mv. d.c. has been obtained with special amplifying circuits.

Thermal or photoelectric amplifiers, which give a much higher level of the signal (from 2 to 3 decades in volts, 4 to 6 decades in power) without going into low-level signals by chopping, appear more desirable, where there are no limitations of space and weight. Unfortunately, they are too slow for high-speed recording. From 100 to 1000 mv. d-c. for full scale moving-coil fixed magnet relays may be used, sometimes in combination with triodes or thyratrons. Always decisive is what shall be called "Step Sensitivity." If we have a range of 100 mv. d.c., we expect the diagram should be sensitive (not accurate!) to a *change* of the magnitude of 0.2% of the full-scale value. If we have a bridge circuit with low resistance in the arms, and a coil resistance of e.g. 200 ohms, we have for a step of 0.2 mv. a current change in the relay coil of 1 microampere and a power of 0.2×10^{-9} watts. This voltage, current or power must release the discharge in the sweep-balance recorder with a time delay variation of not more than 0.2% of the sweep time. If our full scale is not 100 but 1000 mv., we have ten times the current or voltage and 100 times the power and we can use a much less sensitive, more rugged relay.

If the scale characteristic is not linear, the step sensitivity has to be considered for the part of the scale with the highest sensitivity. For a vacuum recorder, which was supposed to have a perfect logarithmic scale from 10^{-5} mm. to 1 mm. pressure, the resistance change in the lowest decade produced a voltage change of 2 mv. in the bridge. The width of one decade on the chart was 1⅝". For the logarithmic scale a step sensitivity of 0.5 mm. or 0.25% of the full scale corresponds to a pressure change of 3% or about 0.06 mv. Whatever type of relay is used, the step sensitivity of the relay and the circuit has to be determined, to find out whether the relay will release the discharge.

DESIGN OF SWEEP-BALANCE RECORDERS

The embodiments of the new method are not designed to compete with satisfactory existing recorders, but to solve recording problems which have not been solved before. For this reason, sweep-balance recorders at the present time are intended mainly for special problems, multi-recording and *X-Y* recording, but not for conventional routine measurements. The drum recorder and the endless strip chart recorder (which is only a design variation of the drum recorder, with extended paper length) offer the best possibilities for new effects, especially high speed and multi-recording.

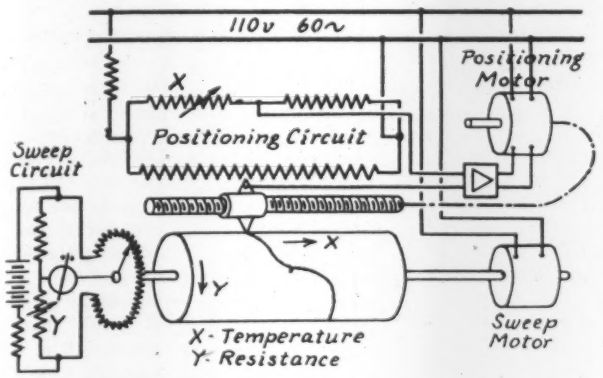


Fig. 4. Sweep-balance *X-Y* recorder, *X*-positioning with temperature and a-c. resistance thermometer. *Y*-circuit on d.c., shown with moving-coil relay. Example shown: resistance change of instrument resistors with temperature.

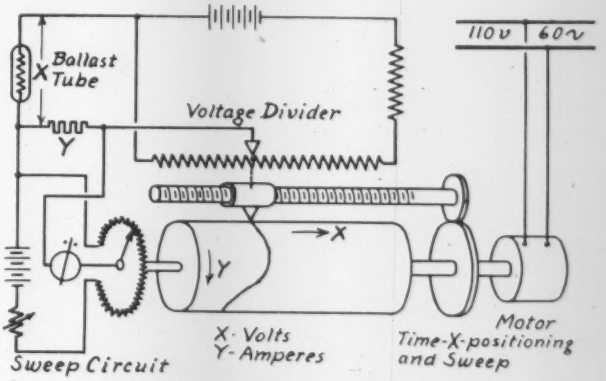


Fig. 5. Sweep-balance pseudo *X-Y* recorder. Example shown: testing a ballast tube, tracing current vs. voltage. Stylus positioned in synchronism with the slide contact on a voltage divider.

high amplification, more influence is to be expected from interference than with high ranges far above the level of industrial disturbances. This refers however to all recorders, not only to the sweep-balance system.

Since we are discussing a new *recording* method, we need not take into account the intrinsic errors of various types of primary elements, pick-ups, transmitters, transducers, etc. Moreover, if any such transmitter has an error of 2% of full scale, it would be futile to exert great efforts to obtain an accuracy of 0.1% or 0.2% for the recorder at the cost of speed.

"Static" and "Dynamic" Accuracy

When we record several magnitudes, we have to compare the duration of one recording cycle (to come back to the same transmitter) with the speed of the change of the magnitude under test. If there are in a process (e.g. in the oil industry[23]) temperature peaks of 10% of the scale range, lasting only one minute or less, and a cycle for 12 thermocouples with one of the step-by-step recorders takes three minutes, then such a peak may be entirely lost and a guaranteed accuracy of 0.1% for the recorder would not preclude the

Drum Recorders

In facsimile recorders the drum, covered with the voltage-sensitive paper, rotates at a constant speed of 1 to 20 r.p.s., the stylus advancing along the drum in proportion with the time (Fig. 3). For sweep-balance recorders and time positioning of the stylus, and 600 points per curve (which means 600 drum revolutions) the minimum total time will be 300 seconds for two drum revolutions per second, and 60 seconds for the probable maximum speed of 10 r.p.s. In other words, the minimum time for a diagram with a sweep balance drum recorder is about the same as the minimum time to record a facsimile telegram. For *X-Y* recorders (Fig. 4) we do not move the stylus with time, but we position it with a second measuring element, operating with a continuous-balance system. This positioning movement in itself causes no marking of the paper; only the rotation of the drum, operating the "sweep cir-

(23) Paul Wing, Jr. and N. A. Miller, "High-speed Temperature Measurements in Petroleum Refining," in "American Institute of Physics Temperature Symposium" (book), Reinhold Publishing Company, New York, 1941, pages 634-638.

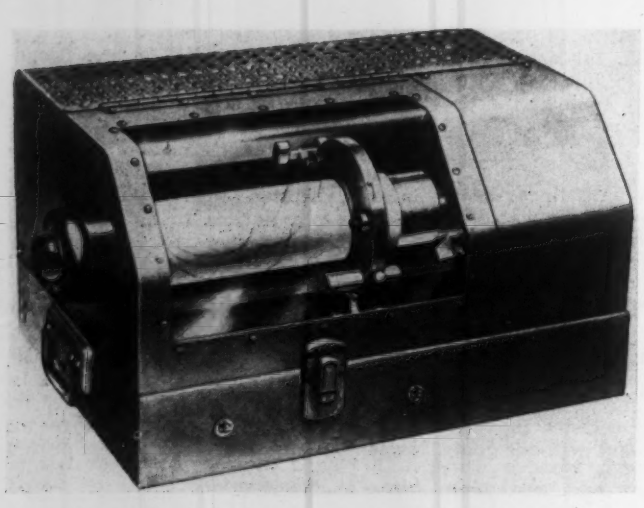


Fig. 6. Experimental sweep-balance recorder with rotary stylus.

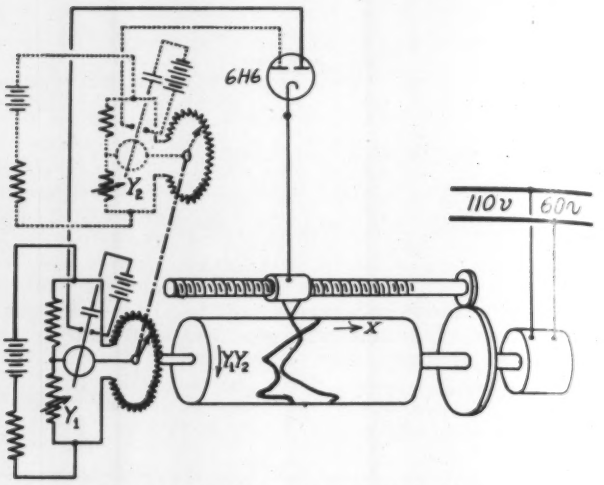


Fig. 7. Double recording with two sweep circuits and one stylus.

cuit," makes a mark on the paper, indicating the position of the balancing element at equilibrium.

Fig. 5 gives the principle of a pseudo *X-Y* recorder used for tracing the characteristics of a ballast tube.

When the drum is rotated at high speed, it is impossible for the eye to follow the tracing of the diagram. By letting the stylus rotate and keeping the drum in its position it is possible to see the progress of the diagram and to obtain even the possibility that the drum can be turned to any position to show that part of the diagram which is the most interesting without even disturbing the recording. Fig. 6 shows such a "Rotary Stylus Recorder" as designed by R. K. Hellmann. The sheet is about letter size, 8½" × 11", 7½" × 10" diagram area.

Multiple Recording

A number of ways are open to trace simultaneously a plurality of diagrams —fifty and even more. Increasing the number of diagrams recorded at the same time may bring about such disadvantages as increase of recording time, loss of speed, or decrease of accuracy.

When we have for instance 48 transmitters assigned to one recorder, we have to distinguish between two time values: time per individual diagram and the time for the total cycle of 48 diagrams. We will see that the latter is not always 48 times the other period, it may be less or it may be more. By using two potentiometer systems it is possible to trace two diagrams with only one stylus, so that with each sweep two markings are made (see Fig. 7). The two circuits can be distinguished by using different discharge energy, so that one line is heavy, the other light. This system might be extended to three and perhaps four diagrams per stylus, but at present this is not being considered. Fig. 8 shows such diagrams, picturing strain versus load, the strain measured with SR4 bonded-wire strain gages. Needless to say that there is no loss of speed with this arrangement. The next arrangement (see Fig. 9) utilizes several potentiometer circuits for 360-degree drum revolution. We may use three, each covering an angle of 120 degrees (minus the necessary loss) or we may use one of 360 degrees, rotating at three times the drum speed and successively connected to three transmitters. This system involves no increase in the number of measuring systems or of the number of amplifiers. However, it reduces the height of the diagram, representing the *Y*-magnitude, and for this reason it impairs the accuracy of reading. If the number of sections is not too great and the diagrams are of the best quality, no practical loss of accuracy need be involved. If we use three sectors, we can get a diagram height of 2.4". One percent accuracy is represented by 0.024" and the reading accuracy, which may be estimated to be 0.012" is 0.5% of full-scale value. Such diagrams, about 4.8" long and 2.4" high, are fully satisfactory for recording within 1% accuracy which is the practical limit for most technical measurements. This limitation of the static accuracy to 1% and at the same time reducing the dynamic error from unknown peaks of 5% and perhaps 10% by the increase

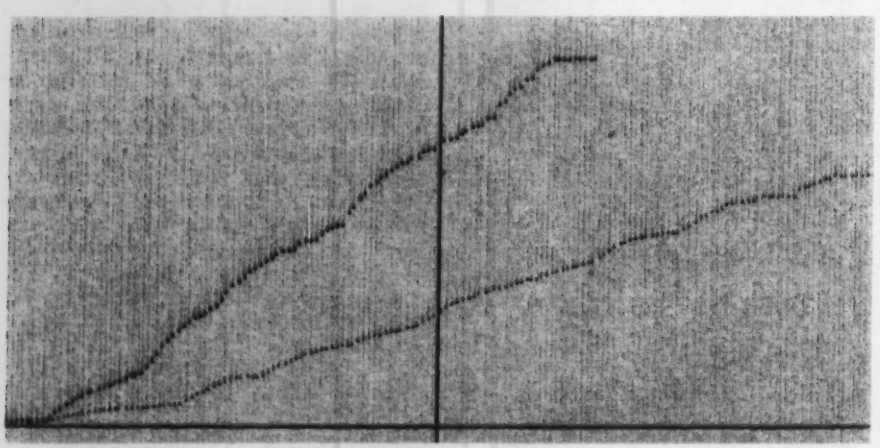


Fig. 8. Recording of two magnitudes on one chart with two circuits of different discharge energies, producing different weights of lines. Diagram size is 5" × 2.2"; illustration is actual size but with left and right edges cut off slightly so that not all the full 5" width of the original is reproduced.

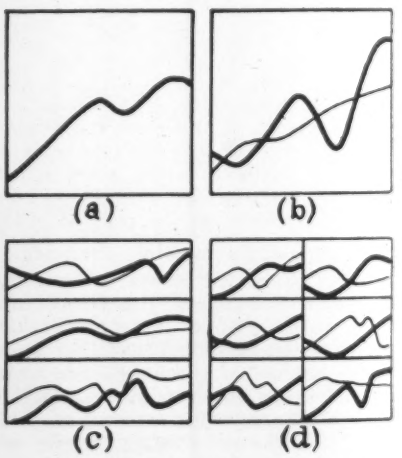


Fig. 9. Subdivision of the chart of a drum recorder to increase the number of recordings per second and the number of diagrams.

For two drum revolutions per second:—

(a) one transmitter, one amplifier, one stylus, 2 points/sec.;

(b) two transmitters, two amplifiers, one stylus, 4 points/sec.;

(c) six transmitters, two amplifiers, one stylus, 12 points/sec.;

(d) twelve transmitters, four amplifiers, two styluses, 24 points/sec.

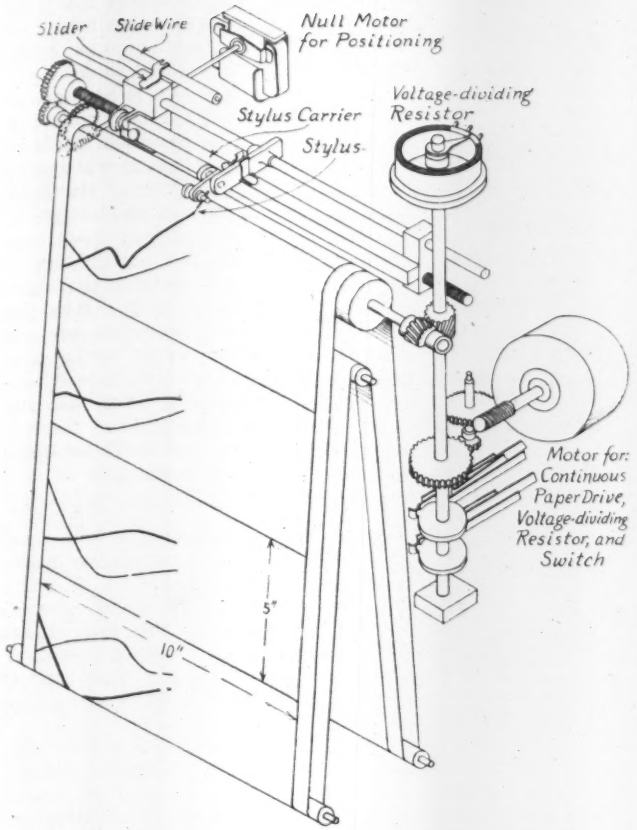


Fig. 10. Isometric drawing of endless-strip-chart recorder, shown with only one stylus and one voltage-dividing resistor.

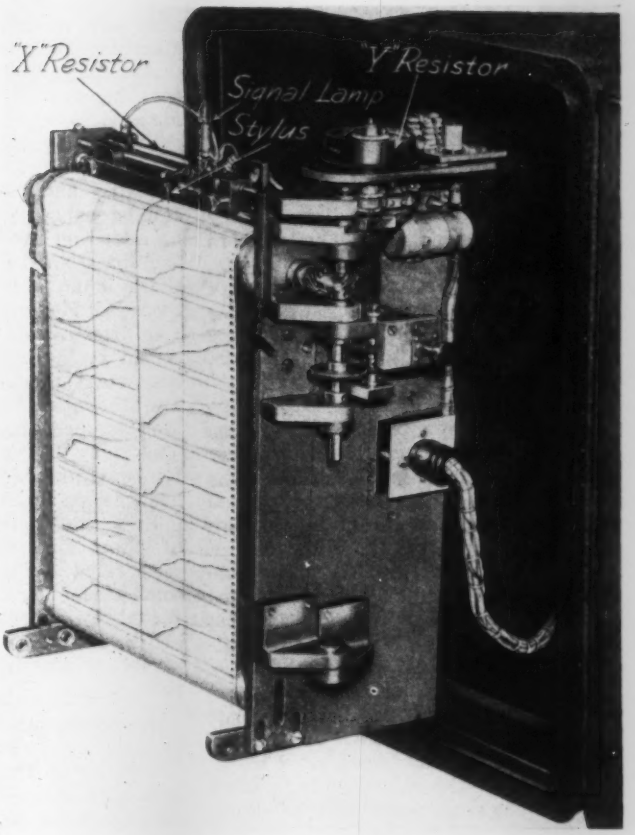


Fig. 11. Experimental design of an endless-strip-chart recorder; chart drive swung out.

of recording speed appeared to be a reasonable compromise.

A further increase of the number of transmitters to one recorder is possible by using not one stylus but two, mechanically connected but insulated from each other, moving together at a constant distance of one-half the drum length. This system likewise involves no loss of speed, but it reduces the size of the diagram to one half. Each diagram covers one-sixth of the total drum surface. We are recording four points with each drum revolution, without increasing the speed of the potentiometer itself and without sacrificing accuracy, except by reason of the shorter *X*-base length. There are required four complete measuring systems, including amplifiers, but of course only one power supply and one *X*-positioning circuit.

Using all three methods of multiple recording, we have now already twelve recordings for each drum revolution. At a very conservative speed of 2 per second, the number of points will be 24 per second. At the speed of facsimile recorders, 5 r.p.s., it will be 60 points per second from twelve transmitters and, with the author's ambition of 10 revolutions per second, the sweep-balance recorder finally should plot down 120 points per second from twelve circuits, ten per circuit, in six diagram spaces each 4.8" × 2.4", provided that it is possible to overcome the mechanical difficulties entailed by such high speeds and to get satisfactory switches, operating at 30 points per second for each one of the four parallel circuits. This appears in no way impossible.

If highest speed is not essential, it is possible to simplify the recorder circuit by using not two, three or four amplifiers and relay circuits, but only one which is switched consecutively to groups of transmitters.

Endless Strip Chart Recorder: Figs. 10, 11.

As already mentioned, this type is basically a drum recorder with stationary stylus and rotating drum, covered with voltage-sensitive paper, longer than the drum circumference. In principle, the potentiometer circuit arrangement is the same as with the drum recorder for one magnitude. While the paper loop is moving, the potentiometer circuit is switched from transmitter to transmitter, until one cycle is completed. For the endless strip-chart recorder the same methods for multi-recording are applied as mentioned in the last section, two diagrams recorded with one stylus, two styluses, and groups of potentiometer circuits switched to up to four discharge circuits. Applying all these methods at the same time gives the highest recording speed; applying them only in part, the speed of recording is slowed down. There are many industrial applications, especially the supervision of production, where only multi-recording is most important and where high speed is less necessary.

For the time being, endless-chart sweep-balance recorders have been standardized for the following performance:

Chart width, net, 10";
Chart length, alternatives, 30" and 60";
Number of diagrams per chart length, 12 or 24;
Height of diagrams, net, 2.2" or 4.4".
Number of diagrams per sheet, 12 or 24 or 36 or 48;
Size of diagrams, 2.2" × 5", 2.2" × 10" and 5" × 10";
Chart speed, 2" or 4" per second;
Minimum time for stylus travel across chart, 10 minutes;
Minimum number of points per diagram with maximum speed, 80;
Minimum time for one cycle of 48 points, 7.5 seconds.

For experimental purposes one recorder has been built for testing quartz crystals, tracing on an 80" chart 144 diagrams in 72 spaces, each space 2.5" long and 1.1" high, frequency and activity, both expressed in milliamperes d.c. versus temperature in the test chamber.[24]

The endless-strip-chart recorder gives the possibility of accommodating many more transmitters to one recorder than the drum with its maximum paper size of about 10" × 10". For high-speed testing the diagram size of 5" × 2.2"

(24) George Keinath, "Multiple X-Y Recorder for Testing Quartz Crystals. *Electronics*, Vol. 18, Jan. 1945, pages 106-111.

appears fully satisfactory: to trace 48 curves, each one with 100 points (a total of 4800 points) takes 750 seconds or 12.5 minutes. If the test is allowed to last one full hour, 23040 measurements are made and plotted into 48 curves, each with 480 points, or about 100 points per inch horizontal length. Where a diagram may take a full day or even a week, the cycle distance may be considerably increased. One cycle in one minute gives 1440 points per day, and this on a 10" long base gives 144 points per inch. For a one-week diagram the chart will be moved only every seventh minute, for a month, once every half hour.

For industrial applications, to supervise temperatures, pressures, currents, etc., a maximum deflection of 4" may appear small in comparison with the standard 10" charts which originated with the mechanical design of the balancing mechanism of the other recording systems. It would have made no sense to have these recorders designed for charts only 4" or 5" wide, the cost would have been the same. With multi-recorders things are different.

We must keep in mind that the chart width for industrial recorders need not be greater than required by the accuracy of the measurements. For a one-curve recorder the 10" width is justified and with high-speed continuous-balance recorders it is actually possible to get 0.5% accuracy. For multiple recorders, for six, eight or ten temperatures, the "dynamic accuracy" comes into the picture too. But, when so many curves are to be recorded on one strip, criss-crossing many times, and having the same shape, given by the nature of the process, it is certainly the recorder with the widest chart which is the most desirable in regard to readability of individual points in this kind of diagrams.

However, if we impose the strict rule that there shall be never more than two curves in one diagram, a scale length of 4.4" is fully satisfactory, giving 0.5% with 0.022" deflection. For this reason the diagram height of sweep-balance recorders with endless strip charts has been limited to 4.4".

Ordinary Strip-chart Recorders

The stylus moves across the chart while several circuits are scanned during this movement, more or less as is done with conventional multi-color recorders. The simplicity of the sweep-balance system, however, allows a greater variety of different arrangements. For instance one magnitude of greatest importance and with a necessarily very wide range (e.g., altitude in a radio flight recorder) may take the full width of the scale, 10", while several others of minor importance and measured with little accuracy (e.g., vertical acceleration and deceleration of the plane) may be assigned only one-tenth of the total width with the second sweep over the same chart.

Different discharge energies can be used to produce diagrams with lines of different thickness. (Fig. 8.)

Any magnitude may be included, also counting operations and position transmitters.

Such strip chart recorders will be useful under extreme temperature and humidity and where very little service can be expected. A date printer may be added on the side of the chart, and the chart not moved at all as long as there is no abnormal condition to be recorded. However when it is abnormal (e.g. for a recorder to supervise the strain on a bridge[25]) a special relay may start the movement of the chart and the operation of the recorder as long as such abnormal condition exists. This may be very low or very high temperature, high wind velocity, ice load, heavy traffic, etc.

Sweep-balance recorders, by reason of their simplicity, being built only with some mechanical gear drives and some electronic circuits, operate unaffected by vibration, acceleration and shock, as long as the whole recorder structure stands up under such exposure.

Applications of the Sweep-balance Method

Instead of analyzing the application possibilities of the sweep-balance method in a more or less theoretical way, a number of specific problems will be described and their solution with the new method given. This does not mean that such instruments are already developed with transmitters and ready for use, or that they could be developed on short notice. Nor can it be expected (for economic reasons) that such new development will be available for individual laboratory problems which may be found, until a number of standardized instruments are in production.

Nevertheless the author feels that some outlook into the possibilities of the new recording method should be given. As has been said before, the new sweep-balance recorders are not designed at present to trace the same type of diagrams as are traced with conventional recorders. Their purpose is to produce a new type of diagram for problems which could not be solved with the existing recorders.

(1) High-speed Starter Battery Tester

Problem: To test each of the three cells, individually and under heavy current load, about the same as under starting conditions. To avoid exhausting the battery with this test, it has to be of very short duration, not more than 30 seconds. During that time at least 50 recordings should be made from each cell.

Solution: Drum recorder with a chart as shown in Fig. 12a, each diagram covering a voltage range from 1 to 2 volts. Two or three drum revolutions per second, hand-wound clock drive, moving-coil relay all 6-volt-operated. Battery discharge resistor 0.03 ohms, drawing 200 amperes at 6 volts. Chart printed with scale and minimum discharge cur-

(25) Anon., "Cause Unknown" (Collapse of Tacoma bridge and Mississippi bridge) *Business Week*, Aug. 8, 1944, page 26.

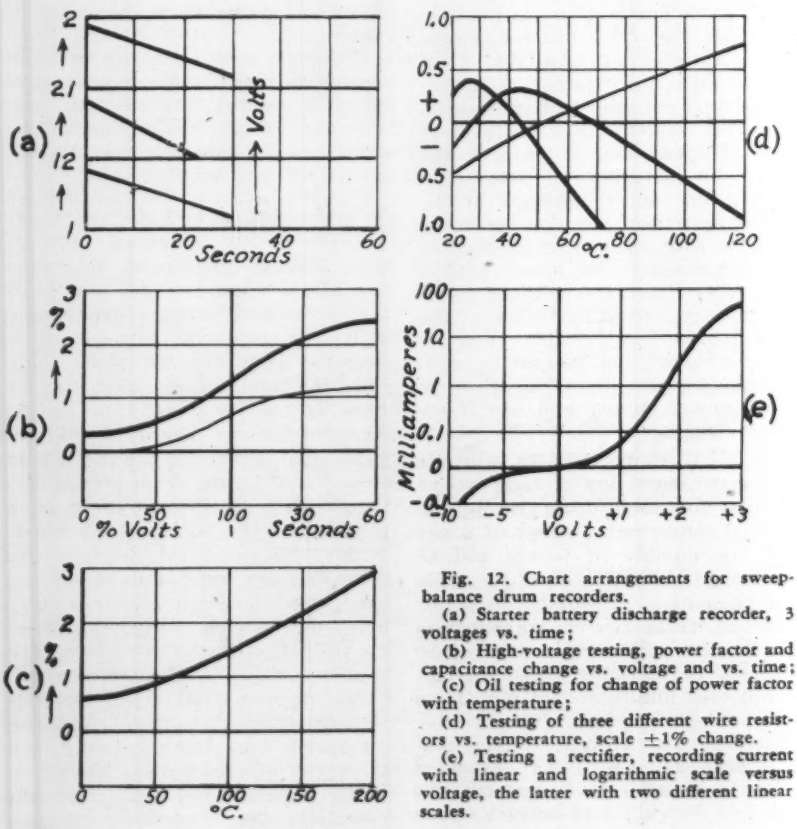


Fig. 12. Chart arrangements for sweep-balance drum recorders.
(a) Starter battery discharge recorder, 3 voltages vs. time;
(b) High-voltage testing, power factor and capacitance change vs. voltage and vs. time;
(c) Oil testing for change of power factor with temperature;
(d) Testing of three different wire resistors vs. temperature, scale ±1% change.
(e) Testing a rectifier, recording current with linear and logarithmic scale versus voltage, the latter with two different linear scales.

rent curves for good batteries. Such a recorder should be welcomed by motorists as well as by battery dealers with good products.

(2) High-voltage Dielectric Test Recorder

Problem: The conventional breakdown test of high-voltage material is unable to give an indication or recording of the happenings during the test, to indicate how near to complete breakdown the specimen had been. Only the recording of dielectric loss as well as capacitance change during the high-voltage test with a high-speed recorder can give such valuable information in the way of "picturized testing."

Solution: Drum recorder of the pseudo *X-Y* type, the stylus positioned first in proportion to the test voltage, then, after reaching the maximum, in proportion to time, generally for one minute. *Y*-measurements by means of electrodynamic or electronic wattmeters or by means of phase sensitive mechanical rectifiers. Range 0 to 3%, power factor as well as capacitance change. Total time of test 2 minutes. 240 points per curve with 2 drum revolutions per second, 1200 points with 10 r.p.s.

(3) Testing of Dielectrics[26] (Fig. 12c)

Problem: The quality and behavior of electric insulation material depend largely on temperature. Two kinds of oil may have about the same loss at room temperature, but one may have ten times higher losses at 100°C. It appears desirable to have a recorder to make such tests in a minimum of time.

Solution: Drum recorder with the same electric circuit as in the preceding case, but the stylus positioned with temperature using a resistance thermometer, the recorder working as a true *X-Y* recorder.

(4) Testing of Viscosity versus Temperature:

Problem: Testing of paint, varnish, oil for viscosity characteristic.

Solution: Drum recorder, using the principle of the Couette or McMichael viscosimeter. The liquid is put in a can on a rotating table. A body (cylinder or disk) is immersed in the liquid and the torque developed by the liquid friction is measured electrically by using a small low-torque slide-wire resistor, generating an emf. in proportion to the torque. This emf. is applied to the sweep circuit. The positioning motor is connected to a 60-cycle resistance thermometer to measure the temperature of the liquid under test.

(5) Testing Precision Resistor Wires and Heater Wires for Change of Resistance vs. Temperature. (Fig. 12d)

Problem: Tests of this kind now require much time. High accuracy is required for the current testing methods. If however the curves of resistance-temperature are automatically traced, their shape and gradient, if only accurate to 0.005% for a ± 1% resistance range, may give all really necessary information.

Solution: Drum recorder, for testing three samples at the same time, switching from one to the other with each revolution. Bridge fed with 1000 c.p.s., temperature circuit with 60 c.p.s. Drum speed 2 r.p.s., test time about 30 min., giving a total of 1200 points for each of the three curves. Only one "sweep potentiometer" is used in this case. Similar recorders are possible for testing bimetals, thermocouples and thermometer wires, comparing the *X*-sample against a standard sample with standard performance.

(6) Testing of Rectifier Disks. (Fig. 12e)

Problem: Rectifier disks are generally not alike. For many applications they have to be selected with the same performance characteristic. Automatic testing with conventional recorders is difficult by reason of the wide current ranges.

Solution: Drum recorder of the pseudo *X-Y* type, stylus positioned together with the slide contact on a linear voltage divider parallel to the rectifier. Two voltage-sensitivities along *X*-axis: —10 volts to 0 volt with 40% of the scale length and 0 to + 3 volts with 60% of the scale length. Current scale in its lowest part 0 to ± 0.1 ma. linear, progressing logarithmically to 1-10-100 ma. Drum speed 2 r.p.s., total testing time 10 minutes, 1200 points per diagram. For mass testing, especially for testing a number of samples at different temperature, an endless strip chart recorder could be used.

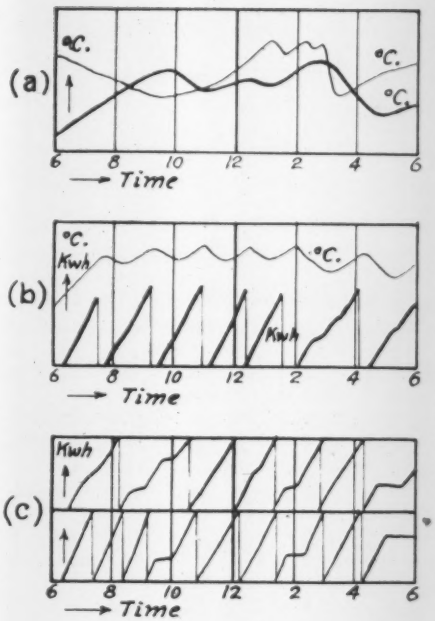


Fig. 13. Chart arrangements for sweep-balance multi-recorders with endless strip chart. Per diagram space:

(a) two temperatures vs. time;

(b) kilowatthours per change and furnace temperature vs. time;

(c) kilowatthours vs. time for welding station;

(7) Temperature Recorder for 24 Controlled Furnaces.[27] (Fig. 13a)

Problem: In order to save space for recording instruments and labor for servicing them, and to give a better survey of a day's operation, it appears desirable to connect a larger number of thermocouples to one recorder than now usual, at the same time giving a better picture than conventional recorders by taking not more than two curves into one diagram.

Solution: Endless-strip-chart recorder, 2 potentiometers. Diagram length, 60″; Diagram height, net, 4.4″; Size of individual chart, 10″ × 4.4″; Cycle length, 30 seconds; Stylus travel across paper with time, 12 or 24 hours; Chart speed, 2″ per second; Number of points per curve, 1440 or 2880.

(8) Temperature, Energy Consumption and Operation of Electric Furnaces. (Fig. 13b)

Problem: To get a full operation picture of a number of furnaces all at the same time, on one chart.

Solution: Endless-strip-chart recorder, same as before, stylus travel across paper in 12 hours. One curve kilowatthours, counted by impulse-transmitting watthour meters which, by means of a step-mechanism, adjust a variable resistor in proportion to the number of kilowatthours. The recorder scans all 12 resistors for the 12 furnaces and records the energy. By mechanical means these counters drop to zero kwhrs with the removal of the charge. The other curve represents temperature.

(9) Welding Station Supervision, 24 Stations. (Fig. 13c)

Problem: To get a picture of the work over one full day, to see stoppages or slowing-up periods, all on one chart. By means of an integrating mechanism it should be possible to determine the net welding time for each welder in a few seconds.

Solution: Endless-strip-chart recorder as before, but only one measuring circuit, and 24 charts, each 2.2″ high. The scale reads in kwhrs; the reduction gear is so arranged that about 10 to 20 crossings per day are made, to make counting easier. Note: While with the recorder of problem 8 the counting was started anew with each recharge of the furnace, here the counting is continuous.

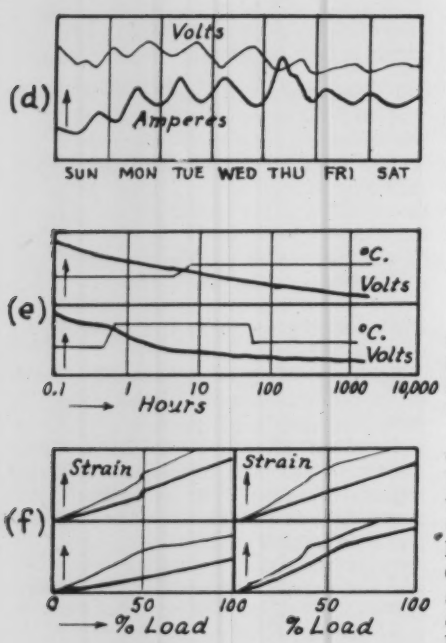
(10) Substation Recorder for 24 cables.[28] (Fig. 13d)

Problem: To give a picture of the load and the voltage variations per hour and per day, to see whether some cables are overloaded while others carry too little current.

(26) P. H. Albert, "Factors Involved in Choosing Insulating Materials." *Radio*, Jan. 1945, pages 22-25.

(27) Anon., "Heat-treating B-29 Superfortress Parts in Mammoth Dodge-Chicago plant. *Industrial Heating*, Oct. 1945, pages 1658-1690.

(28) T. G. LeClair, "Automatic Printing Ammeter." *Transactions AIEE*, Vol. 60, March 1941, pages 93-99.



(Fig. 13 continued)

(d) amperes and volts vs. time, transformer station;

(e) testing dry cells for voltage drop vs. logarithmic time scale, at the same time recording ambient temperature or discharge current;

(f) testing of structures, diagrams of strain vs. load, using two styluses at the same time.

Solution: Endless-strip-chart recorder. Diagram chart length 60″. 24 diagram spaces, each 2.2″ high, 10″ long. Cycle distance, 5 minutes; Chart speed, temporarily 2″ per second or 30 seconds for 60″. Normal stylus travel across chart in 7 days; stylus travel per hour 0.06″, per day 1.44″. Number of points per diagram and week, 2016. Voltage scale, suppressed, 110 to 120 volts a.c., current scale, 0 to 6 amperes a.c. The chart with 2.2″ height allows a measuring and reading accuracy of ± 1%, which appears fully satisfactory, considering that all values of current, voltage and power are a combination of chances, never occurring another day or week within 1%. Volts and amperes are always measured with instrument transformers and rectifier instruments in order to get linear scales. Any other magnitude, e.g. active or reactive power or current may be recorded in place of voltage.

(11) Life Test Recorder for Dry Cells, Capacitors, Electronic Tubes, Heaters. (Fig. 13e)

Problem: Supervising a great number of samples over a short or long period of time which in many instances is not known at the beginning of the test. More than one magnitude to be supervised, e.g. voltage and ambient temperature.

Solution: Endless-strip-chart recorder with positioning of stylus logarithmic with time. Diagram size as in problem 10, 2.2″ × 10″, cycle duration 30 seconds. Number of specimens, 48. Cycle distance variable, beginning with 2 minutes, increasing with duration of test. Scales for dry cell tester 0.5 to 1.5 volts and −50 to + 100°C. Time scale, 1-10-100-1000-10,000 hours. Cycle distance, 1.5-15-150 min.-2.5 hrs-25 hrs-250 hrs. Number of measurements per decade, 100. The logarithmic time scale would allow readings of time with an all-over accuracy of ± 0.012″ = ± 2.5% of the indicated time.

(12) Stress-strain Recorder for Laboratory Load Tests. (Fig. 13f)

Problem: To trace individual diagrams from a great number of strain gages, not as usual strain vs. time, but strain vs. stress. In most cases highest recording speed is desirable.

Solution: Endless-strip-chart recorder for 48 gages. Diagram length, 30″; Diagram height net, 2.2″; Size of individual diagram, 5″× 2.2″ (two curves). Chart speed, 4″ per second, Cycle length, 7.5 seconds. Points per second, 6.4. Number of styluses, 2. Number of amplifiers for sweep circuit and discharge circuits, 4. The same type of high-speed recorder could also be used for many complex testing problems, e.g., testing an airplane engine by automatically plotting all readings in function of air pressure (altitude) or of motor speed (r.p.m.) The possibilities are almost unlimited.

(13) Air-conditioning Plant Supervision. (Fig. 14a)

Problem: To get a picture of the operation of the plant, including data for efficiency.

Solution: Ordinary strip-chart recorder with stylus moving across the paper. Chart 10″ wide. For example:

Outside temperature.....		
	−30°C. to 50°C.	3.2″
4 inside temperatures.....		
	0 to 30°C. total	3.2″
Relative humidity.....		
	0 to 100%	1.6″
Energy consumption kwhrs.....		1.6″
	Total.....	9.6″

Energy is recorded with impulses given by an integrating kwhr meter. Speed of stylus across chart is 10 seconds for 10″. One measurement is made every two minutes. The chart speed is 1′ per hour.

(14) Radio Flight Recorder for Commercial Airplanes. (Fig. 14b)

Problem: To transmit by radio from the airplane in flight essential data and weather conditions at its location to a ground-station recorder.

Solution: One strip-chart recorder is assigned to each plane leaving or coming in. Chart 10″ wide, stylus movement synchronized with the movement of the transmitter on the plane. Recording only one second every minute or every 3 minutes, with one or two sweeps all magnitudes are scanned and recorded. The following may be transmitted:

Altitude,	humidity,
air temperature,	air speed,
r.p.m. each motor,	fuel quantity,
power,	direction.

It appears that the use of such centralized recorders in the large airport terminals would be preferable to the use of recorders on board the planes, saving weight and service to keep them in order. There are no basic difficulties to be expected with the design of such recorders, all the elements have been used for many years in radio-facsimile transmission, radiosondes and commercial radiotelephony. The same principle, with much higher speed of recording, could be used for flight testing.

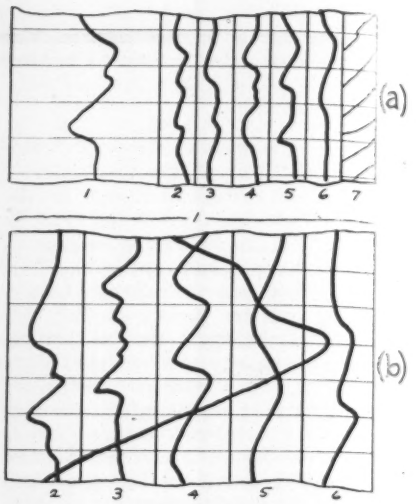


Fig. 14. Scale arrangement for sweep-balance recorders with ordinary strip chart, moved in proportion to time.

(a) Recorder for a heating or cooling plant, tracing outside and inside temperatures, with different ranges and separate spaces, also kilowatthours energy consumption.

(b) Flight recorder for commercial planes with radio transmission of the measurements, two sweeps for one full cycle. Transmitting to a recorder on a ground station: air pressure (altitude), air temperature, engine temperatures, humidity and air speed.

Conclusion

These examples are only a few of a large collection of problems where multi-recording is a necessity. The new method may save much tedious work now done in evaluating the readings when testing vehicles of all kind, airplanes in wind tunnels, ship models in test basins or during launching.

The recording speeds given in the application section of this article are based mostly on actual experience with sweep-balance recording. If high-speed switches can be developed the recording principle appears to be usable for recording speeds far above the figures given here, especially if some sacrifice in static accuracy is made to gain in dynamic accuracy.

Acknowledgment

In giving this first complete disclosure of the sweep-balance method, the author wants to express his thanks to his collaborators at the Connecticut Telephone & Electric Division of Great American Industries in Meriden, Conn., especially to Assistant Chief Engineer R. K. Hellmann, who transformed his thoughts and ideas into reality. He contributed especially the rotary stylus mechanism and he will report later on special designs, circuits and applications of the new recorders.

The Hydrogen Thyratron

By HAROLD HEINS, Electronics Division, Sylvania Electric Products, Inc.

DEVELOPED during the war as a modulator or pulser tube for microwave radar systems, the hydrogen thyratron is now available for industrial and commercial applications.

Two general types of modulators were developed for wartime radar:

The first type of modulator was a high-vacuum tube used to switch a charged capacitor rapidly across the oscillator and, after the required time of pulse, to disconnect the capacitor rapidly. ("Rapidly" means almost instantaneously, as will be explained later.) The capacitance usually stores from 50 to 100 times the charge that flows through the load during a single pulse. The voltage developed across the load decreases exponentially in accordance with the time constant of the circuit but the pulse duration is so short that sharp rectangular pulses are rapidly obtained. The storage capacitor charge is replenished during the time interval between pulses. The voltage required to control the keying tube grid is obtained by amplifying a pulse of the required duration which is formed at low voltage levels.

The requirements for higher power led to the development of the second type, the line modulator. This type also offered many advantages in regard to simplicity, compactness, and reduction in weight. The basic operation is quite simple: If a charged open transmission line is discharged by means of a rapidly-closing switch through a resistance equal in magnitude to the characteristic impedance of the line, a voltage pulse will be impressed across the resistor. The duration of the pulse will depend on the electrical length of the line.

In contrast to the hard-tube pulser, the pulses are formed directly at high levels and the line capacitance is completely discharged through the load at each pulse. The line, or pulse-forming network, is recharged during the time interval between pulses. The switch must close very rapidly to produce a sharp leading edge of the pulse. After the switch is closed the pulse length is determined entirely by the network or line. Nevertheless the switch must open sufficiently fast so that the line can charge in the interval between pulses at high repetition rates.

One of the first switches used in the application was the rotary spark gap. Although extensively used in the early radar systems, the rotary gap had many undesirable features. Among these were noise, weight, brush and bearing maintenance, and electrode erosion. It was not capable of rapid shifts from one repetition frequency to another, which was desirable in many radar systems. In addition, the rotary gap produced considerable "time jitter": the time spacing between successive pulses varied erratically.

Another form of switch used in line modulators was the enclosed series fixed gap tube. Fixed gaps were enclosed in glass tubes and filled with high gas pressures. Two or more were used in series, depending on the voltage requirements. Triggering or firing was accomplished by a relatively high damped oscillatory voltage applied across one of the gaps. When this gap fired, the applied voltage was sufficient to fire the string of gaps and discharge into the load. The series gaps were characterized by low efficiencies, excessive trigger requirements and a restricted voltage range.

The orders of magnitude of the pulse characteristics used in radar systems may be of interest. Peak network voltages ranged from 5 to 30 kilowatts; peak currents from several to 250 amperes; repetition frequencies from a few hundred to 4000 pulses per second; and pulse widths from 0.1 microsecond to 6 microseconds. The switch tube must be capable of switching high peak voltages and currents. The peak powers involved reached power levels of 2 to 3 megawatts. Because of the short pulses, average power levels were of the order of one-thousandth of these peak levels.

Early in the war, Dr. Germeshausen, of the MIT Radiation Laboratory, proposed the use of the thyratron of special design as a switch tube. Hydrogen gas was selected because its high mobility decreases the deionization time. Helium would have permitted a higher operating voltage for a given gas pressure, but preliminary experiments indicated that hydrogen was superior with respect to cathode destruction by ion bombardment. Mercury vapor was not considered because mercury-vapor tube characteristics are dependent on ambient temperature and because of its relatively high deionization time.

The advantages of a suitable hydrogen thyratron in a line modulator are: (1) light weight and compactness; (2) simplicity of circuit construction and servicing; (3) precision timing, or low jitter; (4) flexibility of operation, simple switching for change of repetition frequency and rate; (5) operation with zero bias; (6) relatively low tube drop at high peak currents; (7) low grid drive requirements; (8) operation over wide ambient temperature.

Early laboratory tubes demonstrated that these advantages could be achieved but that a major difficulty would be satisfactory control of the factors affecting the life of the tube. The company with which the author is associated was one of several tube manufacturers called upon to help complete the development work to get a tube of satisfactory life into production. After a period of considerable development and testing, three hydrogen thyratrons were standardized by the Services.

The fundamental structures of these three hydrogen thyratrons are similar. A molybdenum disk anode is completely enclosed by and closely spaced from the grid structure. Spacing is made considerably less than the mean free path in hydrogen at the operating voltages attained. The control element of the grid structure is a perforated disk below the anode. A baffle mounted below the grid disk gives the tube its positive control characteristic and greatly reduces ion bombardment of the cathode. Particular attention was given to the design details of the anode seal to meet the temperature and voltage requirements. A equipotential cathode with radiation shields is used.

The choice of hydrogen gas introduced many difficulties in tube processing which had to be overcome before satisfactory production and life were obtained. Hydrogen is readily absorbed by most metals and carbon. Metal parts must be saturated with hydrogen to prevent rapid clean-up. Hydrogen also reacts with metallic oxides or carbon to produce products capable of poisoning the cathode. Complete freedom from contamination is of great importance. Purity of the nickel parts, particularly those used in the cathode, is very important. Before satisfactory production was obtained a grade of highly-purified nickel, far superior in purity to the best grades used commercially in other tubes, was developed. Hydrogen also reduces the barium oxide of the cathode coating if the cathode temperature is too high. This restricts the operating temperature range to a narrow region in the vicinity of 800°C. Difficulties with emission occur if the cathode temperature is designed to run low to avoid barium oxide reduction. For this reason *a peep hole is provided in the tube structure to determine cathode temperatures with an optical pyrometer.*

Tube life has improved continuously with improvements of processing techniques. Although a life of 500 hours was difficult to meet originally, life is now over 2000 hours. Further design changes may increase life to 5000 hours.

Applications

Post-war applications of the hydrogen thyratron to be expected will include radar as a navigational aid for ships and aircraft; pulsed microwaves in industrial applications including new methods of heating, forming and bending of glass and plastics; pulse communication systems for multi-channel operation; high-speed welding using pulse techniques; and electroplating with increased speed and denser platings.

(Continued on page 250)

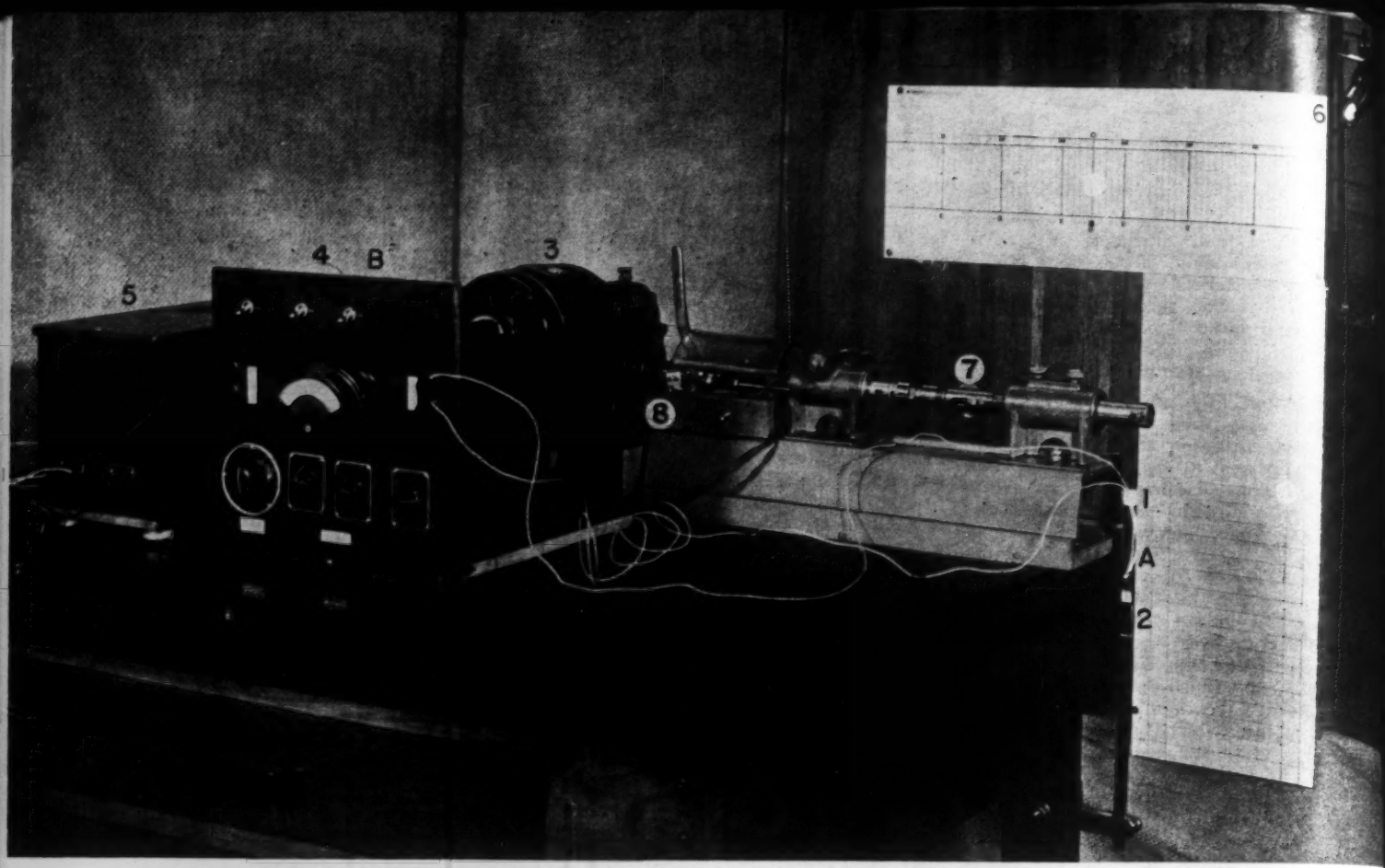


Fig. 1. (A) 1. Calibrated steel beam; 2. SR-4 Strain gage; 3. Reversing motor. (B) 4. Control panel; 5. Recorder; 6. Lamp; 7. Mirror; 8. Adjustable screws.

A Versatile Automatic Method of Measuring Torque and Counting Load Cycles

By JEROME J. WOLKEN, Mellon Institute of Industrial Research, Pittsburgh, Pa.

This article describes an automatic torque apparatus developed to enable the rapid and accurate evaluation of frictional resistance to rotary motion. Designed especially for testing the locking effectiveness of war-important nut-bolt assemblies, the apparatus can be adapted to other engineering uses. Readings may be obtained electrically or optically, with or without autographic records. The equipment differs from other torque-measuring devices in two respects: (1) it is designed to measure both the "on" torque — say clockwise—and the "off" torque; (2) it permits any number of turns and registers this number.

A LARGE variety of problems arose in wartime in the manufacture of self-locking nuts, used by the thousands on aircraft, and the consequent researches led to many technological advances. An illustration is the development of suitable apparatus for testing and controlling the locking effectiveness of individual nuts, which is usually measured by the value of the torque required to thread a bolt into the nut. Several different types of torque machines have been employed for this purpose. In one apparatus the resistant torque is measured by the calibrated movement of a pendulum attached to a shaft to which the torque is imparted. In another type the resistant torque is read by calibrating the twist of a long shaft instead of the rotation of a pendulum. In both these machines, however, it is difficult to obtain an accurate torque reading because of the inertial effects of the rotating beam or of the twisted bar. Other disadvantages are their large size and their being manually operated.

Consideration was given to overcoming the inertial effect of the pendulum system by immersing the pendulum in various liquid media. Another procedure that was tried embraced the use of sylphon bellows and pressure gage, where the resistant torque would be employed to compress the bellows and increase the pressure of the liquid therein. Still other methods that were investigated included the use of calibrated springs and of standard type torque wrenches.

After examining the advantages and disadvantages of these methods, they were all discarded in favor of a system in which the torque was recorded by the deflection given to a calibrated steel beam supported as shown in Fig. 1. In addition, a machine was built which was mechanically operated and automatically controlled. The applied torque values are counteracted by the deflection of a flexible steel beam and can be measured either by a calibrated SR-4 type of strain gage[1] or by a calibrated optical lever method. In either case, results are considerably more consistent than those obtained by the rotating pendulum or twisted bar methods.

In the machine illustrated in Fig. 1, all parts, with the exception of the motor, were designed and built in our laboratory. The mechanized unit automatically assembles and disassembles a stop nut on a bolt. It is constructed so that the number of bolt threads penetrating the nut can be increased or decreased as desired depending on the length and size of the bolt. Each application and removal torque is automatically counted.

The torque required to thread the bolt through the self-locking nut is measured by the deflection of a calibrated steel beam (see A in Fig. 1). The beam is fixed firmly at one end of the shaft and held by an extension fixture with two knife edges at the other end. The deflection of the beam is

(1) A. V. deForest. Characteristics of Wire Strain Gages. *Instruments*, Vol. 15, 1942, pages 112-114, 136-137.

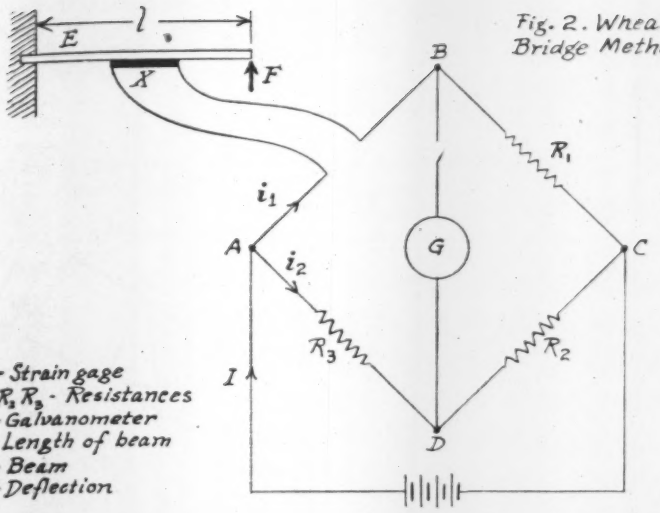


Fig. 2. Wheatstone Bridge Method

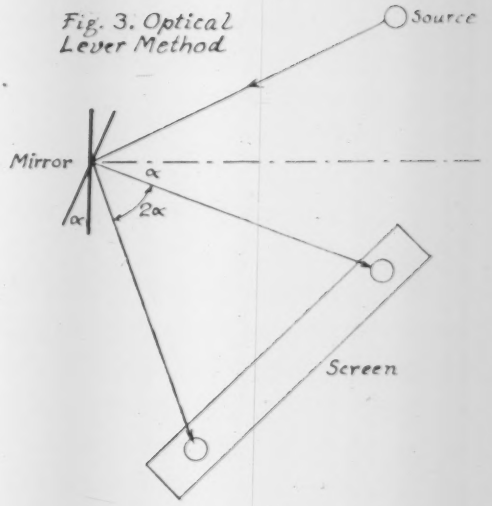


Fig. 3. Optical Lever Method

proportional to the value of the applied torque. The range of torque values over which the instrument will record depends upon the length of the steel beam, which is adjustable. The deflection of the flexible beam, hence the value of the applied torque, is determined by recording the change of resistance of an SR-4 type of strain gage, fastened rigidly to the beam. The principle is shown in Fig. 2 (which will be self-explanatory to most readers). The strain gage is of cupronickel with an electrical resistance of $119.7 \pm .01$ and a gage factor of 2.04; this gage is cemented to the center of the calibrated beam. If a small load of 2 lbs. is applied to the gage and 24 hours allowed for setting, the strain gage will be permanently fixed. After being set, the strain gage need never be removed unless injured in some manner. Greater accuracy of results can be obtained by cementing a strain gage on either side of the beam. This procedure compensates for any temperature changes that may occur and more accurately records the strain exerted on the beam as the torque changes from its maximum "on" reading to its maximum "off" reading.

For convenience of operation, the electrical apparatus required for the determination of the resistance changes of the SR-4 strain gage has been assembled in a small compact portable unit. This unit, indicated by B in Fig. 1, houses the Wheatstone bridge, the battery, the ammeter, the switches, and the rheostats for adjusting the Wheatstone bridge and galvanometer.

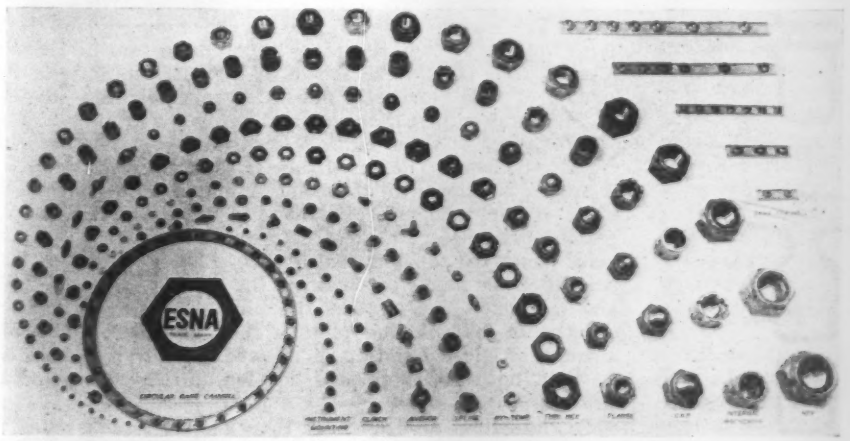
If desired, the torque values can be recorded automatically and permanently by using one of four standard types of recorders, namely, (1) Speedomax, (2) Crystograph, (3) magnetic oscillograph, and (4) cathode-ray oscilloscope. With the exception of the Speedomax, none of these instruments suffers the disadvantage of having a considerable inertial mass. If accurate values of *on torque* and *off torque* are all that are required, the Speedomax will do an adequate recording job. If, however, the instantaneous or "breakaway" torque or a continuous recording of torque versus thread penetration is required, one of the other three recorders is necessary. With the Speedomax and Crystograph an ink recording of the data can be directly obtained. Where the magnetic oscillograph or the cathode-ray oscilloscope is used, either visual or photographic records can be obtained.

A somewhat simpler arrangement for recording deformation due to the applied torque is easily obtained. In this method (see Fig. 3) instead of attaching a strain gage to the flexible beam, in order to record its change of length, a small mirror is firmly fastened to the *shaft* to which the flexible beam is rigidly attached. As the shaft is caused to twist by the action of the applied torque, the value of the twist, which is found to be proportional to the value of the applied torque itself, is determined by the movement of a beam of light reflected from the mirror surface. The optical lever method has the advantage of instantaneously picking up any changes that may occur in the value of applied torque without introducing extraneous inertial effects.

In Fig. 1, 7 shows the way the small mirror is attached to the central shaft. As the shaft rotates, the mirror receives light from the source and reflects it back to the screen. A plano-convex lens having a focal length of 1 meter is attached close to the mirror. A lamp on a ring stand acts as the light source. A calibrated screen is used, from which the torque may be visually read and recorded by an observer. For a continuous, permanent record of the data, an 8-mm. or 16-mm. camera may be used.

The measuring technique and type of recorder depend upon the data required. If the torque testing apparatus is to be employed only for instantaneous determinations of the torque values for which no permanent records are desired, it is recommended that the optical method and visual recording be used. On the other hand, if permanent records are necessary, either the optical method in conjunction with a camera or the strain gage method with a Crystograph recorder will be satisfactory. If the apparatus is to be used as a research instrument for determining minute changes of torque, a cathode-ray oscilloscope with a camera will probably be most suitable.

Acknowledgment. The author is grateful to J. A. Sauer, his adviser on the industrial fellowship on locknut technology, for his helpful encouragement in this research at Mellon Institute.



Display showing variety of tested nuts. *Courtesy Elastic Stop Nut Co.*

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

VII. GROUND SURFACES FOR GLASS APPARATUS

(Continued)

MAKING STOPCOCKS *(Continued)*

4. The two outlet tubes should now be prepared. If these tubes are to be of regular glass tubing, a constriction is made in the tube. The glass is cut at the center of the constriction and the end is flattened by the carbon tool. Capillary tubing must be opened by blowing a thick-walled bulb in a capillary and cutting it at the diameter with the burner. The end is also flattened with a flat carbon tool. Both tube ends should have the form shown in Fig. 67E.

5. The rod attached to the shell is taken in the left hand and the outlet tube is held in the right hand. The burner is adjusted to a pin-point flame which is directed against the shell opening and the prepared end of the outlet tube. The glass of both the barrel and tube is heated with rotation until it appears white hot and the outlet tube is *touched* to the barrel *directly* over the hole. The glass is allowed to cool slightly. The point of contact between the barrel and outlet tube is heated with rotation to a temperature which allows the glass to flow sufficiently to give a smooth seal, Fig. 67F. Under no circumstances should the contour of the taper be altered during the above operations. The glass seal is made without blowing into any part of the system and, because the shell and outlet tube have thick glass walls, no distortion of the outlet tube bore or shell taper will be experienced unless the two are pushed together or pulled apart during the operation. The second outlet tube is sealed to the shell exactly as the first. In this case the latter will serve as a handle. The entire assembly is annealed after the second outlet tube seal is completed. Two different outlet tubes of capillary and regular tubing, are illustrated in Fig. 67F to show how each should appear when finished.

6. Several different types of plugs may be made for stopcocks. The hollow plug, solid glass plug or partly solid plugs have been used. The production of the hollow plug will be described first. To make it, the first operation is to set

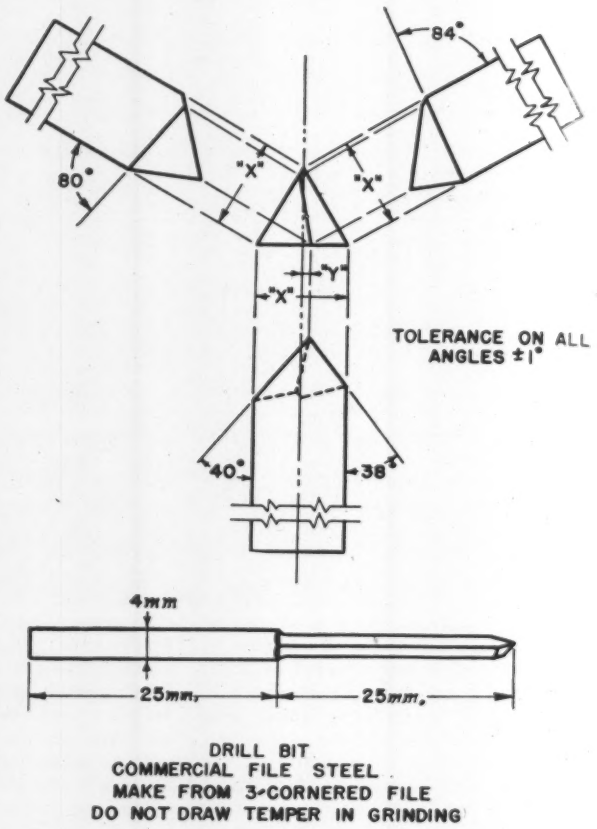


Fig. 69

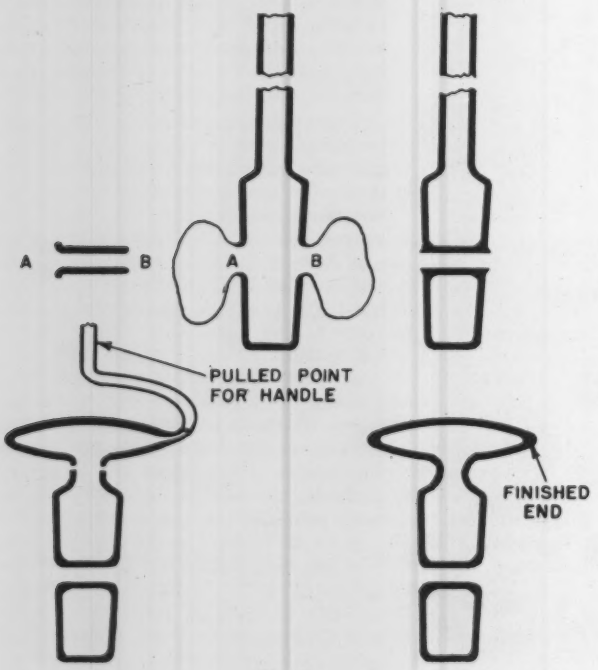


Fig. 68

the required dimensions on calipers so that the taper can be formed. The plug must be made oversize; so the diameter of the scale 2.5 mm. toward the wider end of the scale from the reference point diameter of 12 mm. is set on a caliper. Two calipers are then set for diameters 15 mm. to the right and left from the first caliper diameter setting. The plug is then started by sealing 8 mm. tubing to an 18 mm. tube, 4" in length. This small tubing will serve as a point while a point is drawn on the larger tube. The taper is then made by the procedure outlined in making the taper for the inner member of the taper joint. Instead of cutting the end open, the end is closed by drawing it down sharply and removing excess glass. The end is tooled square as shown in Fig. 68. It is quite important that the three taper diameters be correct. A small tube is made as shown in Fig. 68. The internal diameter of this tube is 2 mm. The taper is then marked at the center caliper diameter and two bulbs are blown, Fig. 68. The glass of these bulbs is scraped away and the holes are fire-polished. The small tube is then inserted with ends A and B positioned in the holes A and B of the plug. The glass of the tube and plug at A are sealed. The tube is reamed periodically to keep it open and uniform, and the glass along the taper is tooled with a flat carbon tool. The seal at B is made by heating the end of the bore tube and tooling it out against the plug. The seal is finished exactly as seal A. The plug is then annealed. A certain amount of glass build-up is allowed as shown in Fig. 68 so that no thin spots will develop during the grinding process.

7. The barrel and plug are then ground to size with the standard grinding tools. A grindaway of 2.5 mm. was al-

lowed and one should be careful that exactly this distance of grindaway is taken, because the holes in the plug must be aligned with those of the shell.

8. The plug handle is then made as shown in Fig. 68 by side sealing the plug tubing to another tube and shaping it as shown.

The technique of shaping solid stopcocks plugs is similar to the shaping of hollow plugs except that in this case solid glass rods are used and the taper is formed by drawing and tooling down the glass. Commercially, solid plugs are molded. Glass for grindaway must be allowed. The

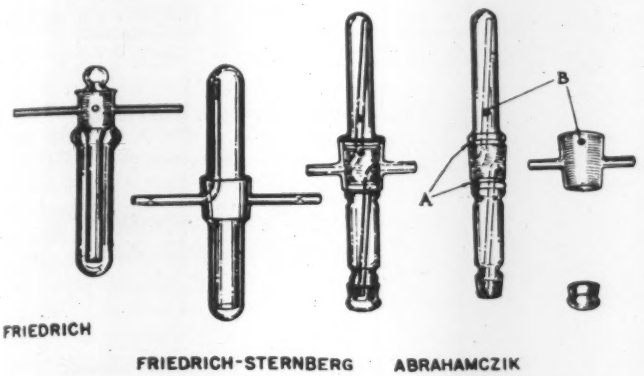


Fig. 70

bore, however, is made by drilling a hole through the glass. This technique has not been discussed. A procedure for drilling holes in glass plugs is as follows:

1. It will be assumed that the solid glass plug has been shaped to the desired taper. The position of the proposed hole is marked. The drill which is used is made from a three-cornered file and is made according to the drawing in Fig. 69. Two bore sizes are listed in the dimension log of Table 10. The drill is hardened by heating, with sub-

TABLE 10

Size of Drill	"X" ±.001"	"Y"
2 mm.	0.0682"	1/64"
3 mm.	0.1023"	1/64"

sequent quenching in mercury. The plug is placed on a vee block which has the angle of the standard taper. The hole is drilled from both sides of the plug to avoid chipping the edges of the bore. Turpentine is suitable as a lubricant in the drilling operation. The plug is then ground in a standard taper socket by the procedure described for the hollow stopcock plug.

Regrinding and Testing Stopcocks and Joints

Standard taper stopcocks and joints are not recommended for vacuum work. The plug or inner member must be ground into the barrel or outer member in the last stage of the grinding process to make the seal required in vacuum systems. Standard ground joint and stopcocks may also be ground together, but in all cases the characteristics of interchangeability are lost. A 900-mesh grit is usually used in this work. One must be especially careful in finishing stopcocks or the outlet tube holes will partly pass the bore hole.

Several methods for testing the degree of leakage in a joint or stopcock have been used but each has shown unreliable results. A simple test is made by cleaning the ground surfaces and wetting them with water. The two members are then put together and an attempt is made to press the inner member to one side. If the seal is poor, a movement in the water contact can easily be seen.

Special Design of Stopcock

Numerous special designs can be given for the development of intricate stopcocks. As a specific example a micro analytical absorption tube will be described. Several absorption tubes are shown in Fig. 70.[3, 4, 5, 6] The Abrahamczik absorption tube was modified as shown in Fig. 71.[3, 7] Its use has been discussed by R. O. Clark and Gordon H. Stillson.[7] The fabrication of this absorption tube is straightforward but is more difficult than the production of a standard stopcock. The glass joint is necessarily thin for low total weight. A brief description of the fabrication of this special stopcock adaption is as follows:

1. The outer member is made by reaming out a tube for a 12 mm. standard taper joint. The taper is then cut to a length of 16 mm. and two outlet tubes shaped as shown in Fig. 71 are sealed to the shell much in the same manner as the outlet tubes were sealed to the shell of the standard stopcock barrel. A spot of colored glass is fused to the shell for an indicating mark. This shell is then annealed, allowed to cool, and ground with a standard grinding tool. A small amount of grindaway is left for grinding the inner member into this outer shell. All grindaway calculations and allowances are made by using the standard taper scale.

2. The inner member is made by first drawing a standard taper to fit pre-set calipers and the large and small ends are drawn down to 8 mm. Thin-wall tubing of this size is then sealed to each end. The taper for the joint which is to serve as the opening for charging the absorbent is then shaped. Two inner tubes are made to form with flat open ends. The ends of the tubes which are to be sealed to the inner member are shaped to contact exactly the tapered wall. These tubes are sealed to the inner member by the procedure used in starting a ring seal. They are held in place in this operation by stiff wire. Instead of blowing out the glass over the two sealed tube ends, a pointed tungsten rod 0.06" in diameter is held against the center of the seal and turned rapidly as it is heated to red heat. The force applied to the hot rod opens a smooth hole into the sealed tube. An indicator mark is fused to the tube above the joint. One end of the absorption tube is closed and the assembly is carefully annealed and ground in a short grinding socket. Two lubricant retaining rings are ground into the surface of the inner joint by using an

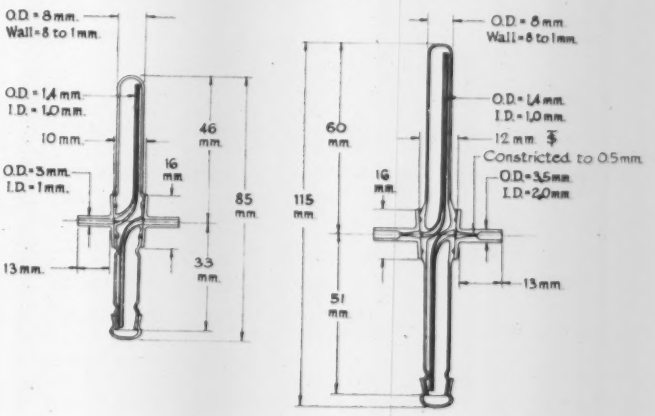


Fig. 71

abrasive cutting wheel and rotating both the wheel and joint to give a groove of even depth.

3. The inner and outer members are then ground together until the holes match exactly. The small cap is then made. This cap and the taper on the end of the absorption tube are ground individually and finally together to give a good seal.

Many similar examples can be given in making small or intricate joints or stopcocks, but the foregoing suffices to challenge glass workers for the development of special equipment.

Care of Ground Joints and Stopcocks

All ground joints and stopcocks should be kept clean and free of grit and dirt. Martin Shepherd has suggested that ground surfaces should receive the same care as given optical surfaces. It is certain that if ground surfaces were treated in this manner, considerable time would be saved in

experimental work. Usually stopcocks and joints are neglected in the laboratory. Whenever joints and stopcocks are stored they should be thoroughly cleaned. The plug or inner member is covered with tissue paper and inserted into the outer member. One should also remember that the two outlet tubes are made of glass and that a rapid twist of the plug is dangerous. The best procedure is to use two hands, one for supporting the barrel and the other for turning the plug.

Lubricating Stopcocks and Joints

All ground surfaces should be carefully lubricated. Stopcocks are best lubricated by applying the lubricant at both ends of the plug. No lubricant should be applied near the bore hole. Applicators of wood are suitable. The plug is then inserted and turned slowly in one direction until the lubricant is worked to the center. Joints are lubricated by applying lubricant along the joint length on two sides. The outer or inner joint is then turned until the lubricant is evenly distributed over the entire joint.

Lubricants

Many lubricants have been used with a certain degree of success but as yet no all-purpose lubricant has been found. Some performed satisfactorily when first applied but, upon being worked by the turning of the stopcock plug, thin out and create troublesome leaks. Most lubricants cannot be used successfully over long periods of time, such as six days, especially if the stopcocks and joints are located in vacuum systems, unless one is careful in cleaning the inner member and applying the lubricant at frequent intervals.

Lubricants which are fairly satisfactory for vacuum joints and stopcocks at room temperature or for ordinary routine laboratory work are:

Apiezon—N
Celvacene, light, medium or heavy
Cello-seal
Cello-grease
Cenco-vacuseal, light and heavy body
Sisco Stopcock Grease
Distillation Products Vacuum Grease No. CB-5.
DC Stopcock Grease, high-vacuum type
Myracene—5

The last two lubricants are special silicone greases prepared by Dow Corning Corporation. Since the characteristic of silicones is heat stability, it is quite probable that their exploitation as high temperature lubricants may be quite valuable.

Separation of Joint or Stopcock Members That Are Frozen Together

Stopcocks which have frozen plugs can be taken apart by using special plug extractors which can be purchased. The barrel is placed in a guide and a plug trigger driven by a spring removes the plug by the trigger impact. The plugs may sometimes be removed by applying a 10% solution of Aerosol OT in ethanol. The solution containing the detergent penetrates between the ground surfaces and loosens the plug. This solution is also useful in separating the members of ground joints.

The surest way of separating frozen members of joints or stopcocks is to apply a brush flame over the outside member. Success in this operation depends on two things. First, the flame must be hot, similar to the flame produced by the gas and air annealing burner. Second, the operation must be quickly completed: it is the more rapid heating of the outer member which loosens the joint. Delay in removing the inner member allows it to become heated. If the members do not come apart the entire stopcock or joint must be cooled before another attempt is made.

Flat Grinding of Glass Flares and Couplings

Flat ground flares or couplings are required in glass circuits if the glass must be connected by a joint which can be closed without moving the glass system through the distance required in closing tapered or spherical joints. Two flat couplings are shown in Fig. 72, A and C. The glass for the coupling in Fig. 72A is made by collecting and working the glass at the end of the tube to a round bead and flattening this bead with a flat carbon tool. The capillary flare is made by pressing the fused glass of the capillary together while it is rotated until a heavy-walled ridge is formed. The glass is then cut slightly beyond the maximum diameter, as indicated by the dotted line in Fig. 72B. This procedure is repeated for the second flat of the coupling.

The flared ends of the glass are ground with the respective grinding compounds used in finishing stopcocks and joints.

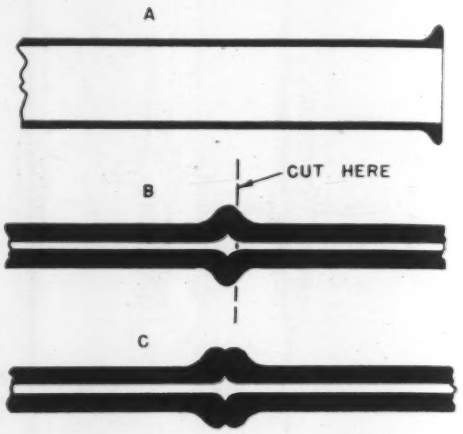


Fig. 72

A flat glass grinding surface is used. A suitable flat grinder, built much in the same manner as a metallographic polisher, is very useful for flat grinding. A glass disk is mounted on the turntable. The grinding compound is put upon the disk with sufficient water to wet the entire surface. The glass is pressed against the rotating disk. In order to avoid breaking the tube when the flare is being ground, the grip should be low, near the flare. The flare is moved from the center to the outer edge of the disk on the side where the latter is moving away from the operator. The flare is rotated during grinding. The entire surface is carefully cleaned with water before the next grinding powder is used.

The finished couplings are lubricated and clamps similar in design to those used for spherical joints can be used for holding the two members together. The efficiency of these couplings is dependent upon the cross-sectional diameter and the accuracy with which the two members are ground. Sometimes it is necessary to grind the two together in the final grinding stage, but this can be accomplished only if a guide is made to hold the two tubes in an exact perpendicular position. The flat flare shown in Fig. 72A can be used in making optical glass cells. The optical glass is sealed to each flared end by using suitable sealing cement.

Ground Glass Check Valves

Check valves are used in glass systems for the intermittent flow of gases or liquids. They are sometimes installed to prevent certain liquids from escaping into other parts of a closed system. Liquid or gas pumps also are fitted with suitable check valves.

Three of the more common and reliable types of check valves have been chosen for discussion. The check valves shown in Fig. 73 are incorporated in automatic Toepler pumps which are used in transferring gases. The procedure in making the valves is quite simple. Two floats are made as shown in Fig. 73. The extension tubes which are open serve as handles for grinding the float against the body. The floats are ground into the body to form a check seat. One is nearly filled with mercury and tipped off. The second is left empty because it must operate as a float. The floats are then sealed into the body by making the second reduced seal. Four glass indentations are made to center the check. These indentations are made by heating a spot on the shoulder of the body and pushing the glass toward the check with the point of a three-cornered file. Toepler

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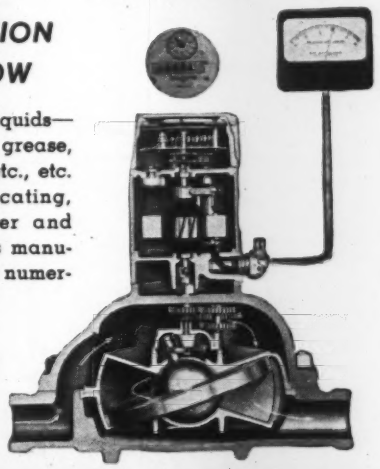

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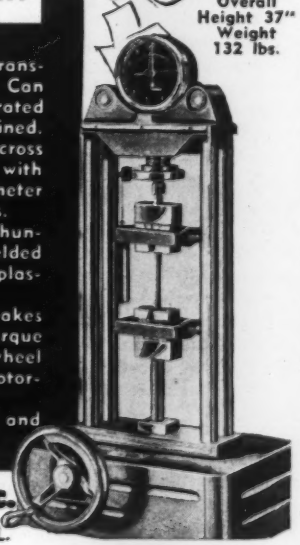

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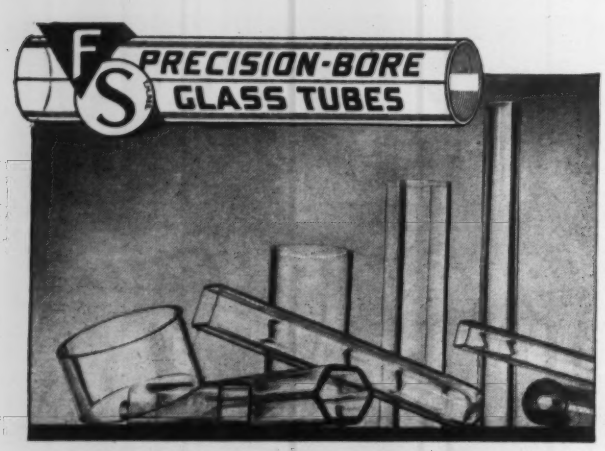

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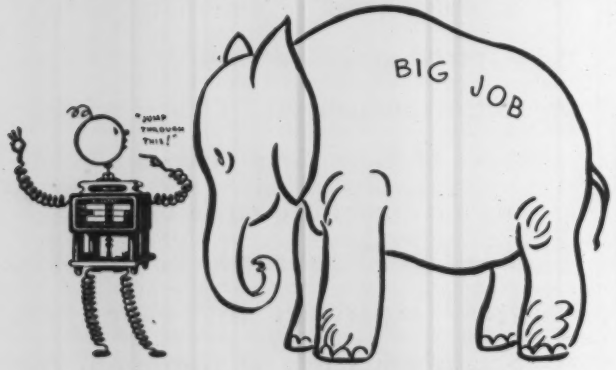

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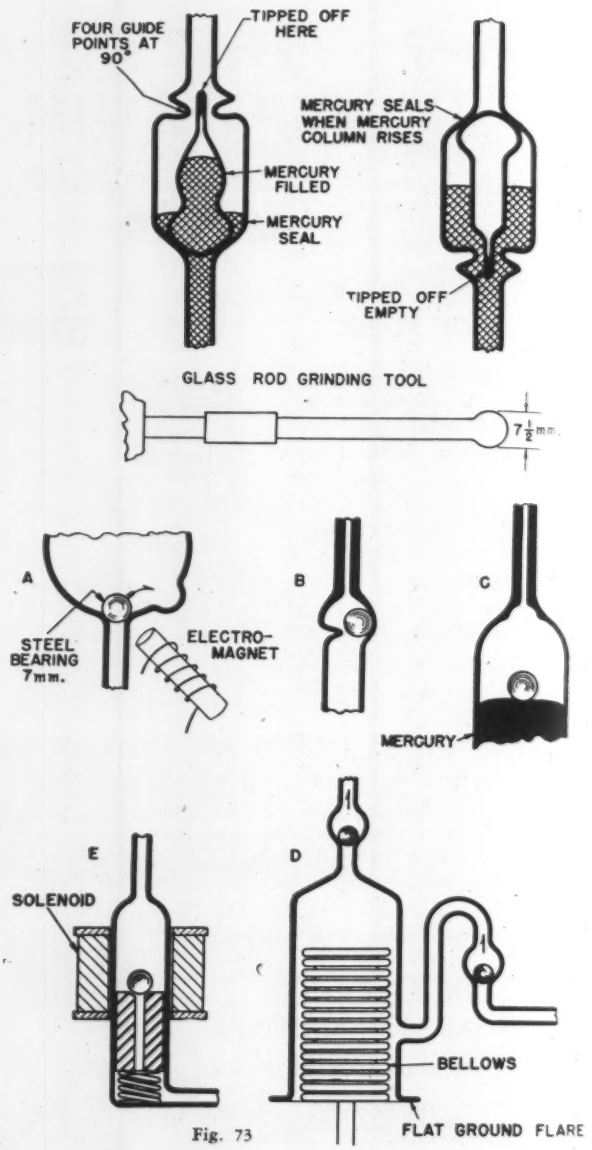

Fig. 73

pumps normally use mercury as a confining liquid and this helps in forming a seal, either by getting above the check and forming a seal with the check seat, or, forcing the empty float of the second valve against the ground seat. It should be noted that the ground seat is a combination of a taper on the body, and a sphere on the float.

Ball check valves with metal or ground glass balls are shown in Fig. 73. A metal ball is used for the check ball in Fig. 73A. The body of the check is made by joining a small tube to a larger tube. A small indentation on the shoulder serves as a holder for the check ball which is moved with an electromagnet. The check seat is ground with the glass rod grinding tool made in the form shown in Fig. 73. This rod is made by fusing the end of a glass rod until a solid glass sphere is obtained with a diameter of 7.5 mm. This rod is wrapped with Scotch tape and then mounted in the grinding chuck. The four respective grinding compounds are used in the grinding process. The glass sphere of the tool is ground to a taper as the grinding proceeds. This is advantageous because the ball will seat better against a taper than against a curved surface.

The check valves shown in Fig. 73B and C are used extensively in gas analysis apparatus. The check in Fig. 73B is made by sealing a tube to capillary tube and forming a small bulb at the seal. The former is cut about ½" from the seal. The check seat is ground into the capillary. In order to confine the ball in the bulb with as small a dead space as possible, it is advisable to hold the former to the

Electronic

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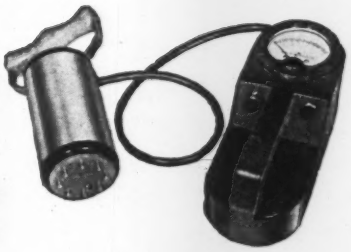

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This compact, lightweight pyrometer is mounted in a magnetically shielded metal case, providing for accurate temperature readings in shop and general industrial use as well as in the laboratory.

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Type 1500 is available as a single circuit pyrometer with a choice of ten scale ranges, 0-400 to 0-3000 F, or as a double or triple range instrument built to order with scales as specified. Centigrade scales can be furnished. Write for descriptive bulletins.

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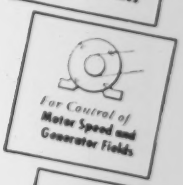

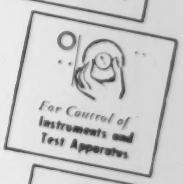

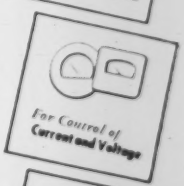

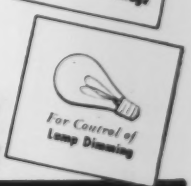

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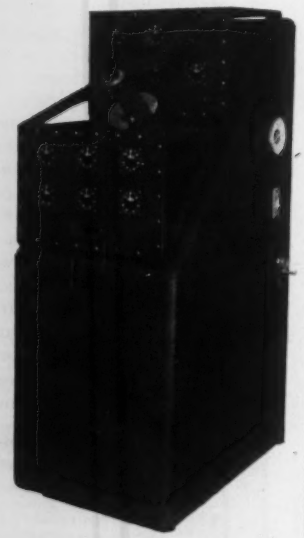

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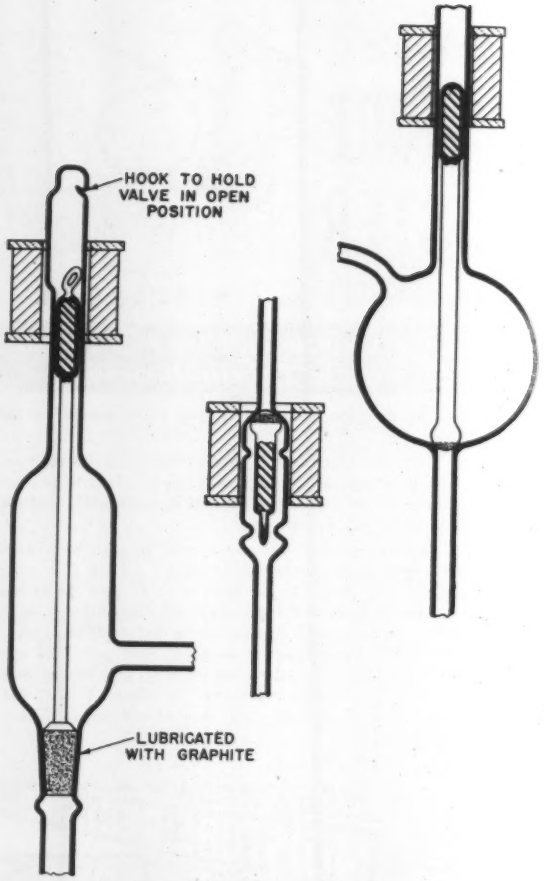

seat by connecting a vacuum line to the capillary. The tubing is then sealed to the bulb and an indentation is made with the end of a file. This indentation keeps the ball from forming a partial seal at the other outlet of the bulb. The arrangement of two simple ball checks sealed into bulbs is shown in Fig. 73D. These checks serve as the inlet and outlet checks for a small sylphon bellows displacement pump.

Another pump arrangement is shown in Fig. 73E. The metal plunger is activated by a solenoid. The ball operates as a check by sealing on the upward stroke and releasing on the downward stroke.

In some of the check valves described thus far, glass balls have been recommended. These can be purchased from Fisher Scientific Company. The diameter of the ground-surface glass balls is 7 mm. If special sizes are needed, glass balls can be made by gathering glass on the end of a rod to the correct size. This ball is then cut by sticking a small rod to the glass and cutting the original rod from the ball. If the glass is not flowed too much, the attached rod can be broken away. The ball surfaces are ground by placing several balls between two glass plates, one of which is wetted with grinding compound. The top plate is then pressed against the balls and pushed in a circular motion.

The operation of glass valves or checks by an electromagnet has offered a satisfactory means of controlling glass and liquid flow. Valves of this type are shown in Fig. 74. The soft iron core is enclosed in glass. The glass is prepared to fit over the iron core which is then heated until the iron turns blue. It is then immediately dropped into the glass and the latter is sealed. The fabrication of the valves is straightforward and need not be discussed.

To be continued

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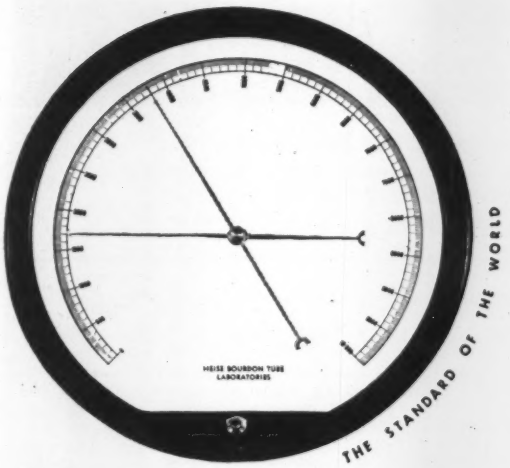

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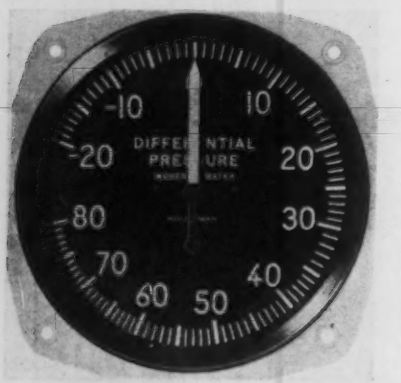
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Differential Pressure Gages

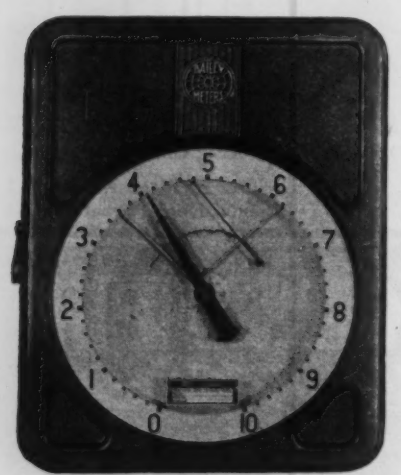
New "Type 254 BK" differential pressure gages are diaphragm-operated instruments similar in principle to air-speed indicators: one pressure connection to inside of diaphragm, the other to air-tight case surrounding the diaphragm. Absence of mercury or other manometric liquid makes instruments portable, eliminates position error, permits observation of fluctuations without



dynamic error and obviates need of checking liquid periodically. Six models are announced, for positive or positive-and-negative (zero-center) differentials, with graduations in inches of water or of mercury to a maximum of 3" of water (max. line pressure 150 lbs./in.^{2} permissible by use of extra-thick glass front). All gages are standard 3⅛" size, can be easily mounted on airplane-panel-type test stands, are designed for important test work or critical flow-measuring applications where both sensitivity and accuracy are required.—*Kollsman Instrument Div., Square D Co., Elmhurst, L. I., N. Y.*

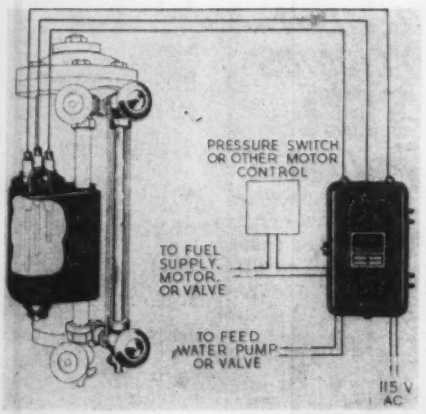
Oxygen Recorder

New automatic continuous analyzer for indicating and recording oxygen content of a gaseous mixture is applicable to boiler furnaces, kilns, many types of metallurgical furnaces, glass tanks, chemical and petroleum processes. It provides a graphic analysis almost instantly, and is said to be responsive to changes of 0.05% oxygen. Sustained accuracy is said to be within 0.25%. Operation: A continuous gas sample is mixed with a vaporized liquid fuel and burned on a catalyst-filament which reaches a temperature proportional to oxygen content. Filament resistance is a function of temperature and a simple resistance bridge is connected to a null balance electronic recorder which may be calibrated in Excess Air, Percent Oxygen, or other desired terms. A high-speed sampling system for handling dirty high-temperature gases is furnished with the instrument when required. High speed of instrument makes it suited for traverse studies and other types of test work, as well as continuous day-to-day operation.—*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*



Boiler Feedwater Control

New "Type B177N Fireye Boiler Feedwater Control" for commercial and industrial boilers maintains desired water level through valve or pump control and instantly cuts off fuel supply and sounds an alarm at a predetermined dangerous low-water level. It operates without any moving mechanical elements; only contact with the boiler is through an auxiliary fitting containing metal probe rods which determine the control levels. It is said to require no



maintenance whatever because there are no moving elements and no vacuum tubes. Probe fitting is mounted parallel to the water column and wired to "Fireye Control." Probes within probe fitting mark boiler feedwater pump-on and -off levels and a low-water danger point. When water falls below middle probe, "Fireye" closes circuit controlling pump and water feeds into boiler until top probe is reached. Lowest probe defines danger point below which boiler water must not fail. Should water drop below this safety probe, "Fireye" immediately shuts off fuel supply and sounds an alarm. Specifications: supply: 115- or 230-volt 60-cycle a.c.; Output: 10 amperes at 115 volts or 5 amperes at 230 volts a.c.; Relay contacts pure silver; Housing: Pressed steel, dust-tight, weatherproof.—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Interval Timer

New "Model E Interval Timer" is designed to control running time of process equipment; to control duration of exposure, as in x-ray machines; to close one circuit and open another at a predetermined interval or to operate signal after a certain time interval. It is said to represent a definite advance in the design and mechanical construction of this type of equipment,

stressing the following specific features: larger dials designed for easy reading and easy setting; sturdier frame construction permitting greater precision in original assembly and the promise of longer life; simplified screw mountings designed to conform to standard instrument practice so that timers may be grouped on instrument panels in combination with other typical control and indicating instruments to complete the installation.—*R. W. Cramer Co., Centerbrook, Conn.*

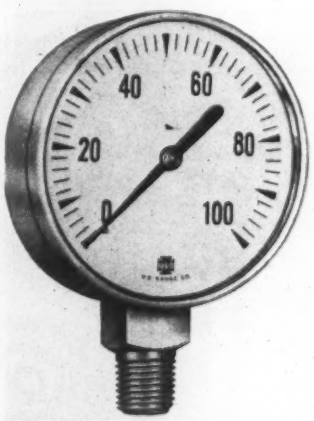
Operation Recorders

New "Operational Recorders" provide a continuous record of "time on" and "time off" of multiple operations including process timing, periodical operations which can be connected electrically such as boiler blowdowns, time study work, the time when a particular check is made, etc. Instrument is available with a single-acting pen, two-

position double-acting pen or a three-position pen. As many as six single or double-acting pens can be combined on a single chart. It can be supplied in 115 to 230 volts a.c. or with special voltages on application. A-c. clock mechanisms are available from 15 minute periods to 8 days. Double-acting pen is now being used in maker's "Normality" indicators, such as "Hazegage," "Gravigage," etc., to record the operations of their indicators. When operation is normal a circle is traced. If process goes too far in one direction, pen moves outward and remains there till "normal" is resumed when pen returns to center point. If process goes too far in the other direction, pen moves to other side of "normal" and remains there as long as condition persists. As many as six of these three-position "Normality" pens can be placed on one chart.—*Ess Instrument Co., Bergenfield, N. J.*

Pressure Gages

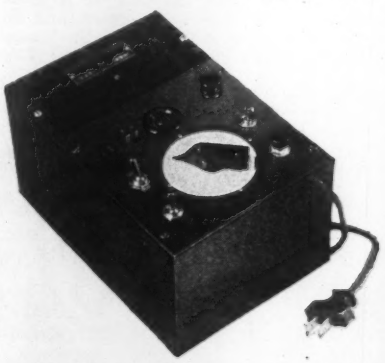
New complete line of pressure gages are said to be streamlined and of a "modernized, eye-appealing design . . . superior in



construction, appearance and readability." Neutral gray case ivory-toned dial with contrasting red and black graduations.—*United States Gauge Division, American Machine and Metals, Inc., Sellersville, Pa.*

Automatic Timers for Intervals From 0.05 Second to 50 Seconds

New "Electronic Process Timer" closes or opens electrical circuits for an adjustable time interval. It is designed especially for timing of short intervals such as a few seconds or fractions of a second, where timers incorporating clockwork or motor may not be sufficiently accurate by reason



of inertia of mechanically moving parts and slip of friction clutches. Timing period can be easily adjusted by means of a stepless control on the panel. Timer is actuated by a push button or by remote control. Upon actuation, a charged capacitor begins to discharge, the rate of discharge being controlled by an adjustable resistor. "Model 950" has timing range from 0.05 second to 0.5 second; "Model 951" 0.5 to 5.0; "Model 952" 5 to 50. Double-range and special-range models are available also, for ranges from 0.05 second to 50 seconds. They can be operated on 100-130 volts a.c. of any frequency and also on d.c. After completing the timing period, it does not take more than 1/25 second for timer to be ready for the next actuation. Two or more timers can be connected for sequencing and recycling operations by means of plug connections, without requiring any additional relays or control units.—*Photovolt Corp., 95 Madison Avenue, New York 16, N. Y.*

Operation Recorder

New "No. 0-275 Operation Recorder" is said to differ from any other in that it has a chart that travels about 1½" per minute, yet clearly indicates length of time of as

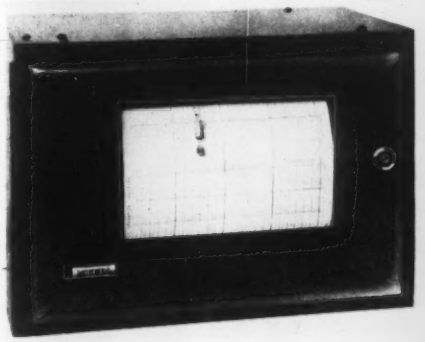


Fig. 1

many as 25 operations per minute for a 24-hour period (see actual-size section, Fig. 2). It may be operated also from any low-voltage contactor or switch making installation, at distant places in a plant, inexpen-

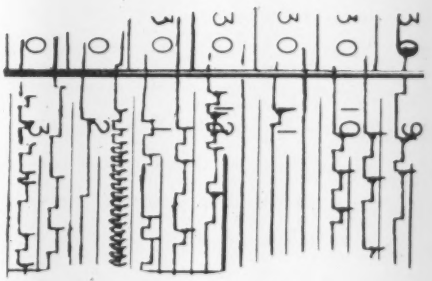


Fig. 2

sively. Ordinary door-bell wire is used to connect contactor with recorder. New instrument makes it possible for a plant superintendent or foreman to check at one control point operations in any part of a plant and gives a permanent daily record of any machine.—*The Instrument Laboratory, Inc., 934 Elliott Avenue West, Seattle, Wash.*

Inductance Decades

New series of Inductance Decades, principally for use in bridge and low-level filter circuits, provide inductance ranges from

0.001-henry steps to 100 henries total. Units are triple-shielded against external fields, are available in enclosed cases with two decades per case. On special order, these can be made with three or five decades in a single case. New decades are adjusted to within 2% at 1000 cps., except for the 100-henry decade which is adjusted at 200 cycles. Inductances will not change appreciably with "quite a variation" of alternating currents or voltages. Useful frequency range of these units is from 30 to 20,000 cps. The 0.01- and 0.1-henry decades have a Q of 40 to 45 at 4000 cps., dropping down to approx. 15 at 400 and 15,000 cps.; the 1- and 10-henry decades have a Q of 35 to 40 at 1000 cps.; dropping down to approx. 15 at 200 and 10,000 cps.; the 100-henry decade has its maximum Q around 200 cps. None of the above decades is designed to work with direct currents through them. However, small amounts are permissible without serious effect on their accuracy.—*New York Transformer Company, 62 William Street, New York 5, N. Y.*

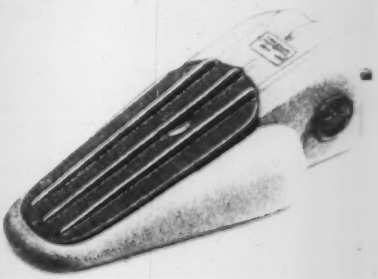
Interval Timer

New "Model P-49 Time-O-Lite" embodies features not in previous models: (1) An additional receptacle can be attached to a

printer platen switch for setting in operation the P-49 at whatever time interval was previously selected. It allows operator to use a foot switch control instead of the push button, if timer is not adjacent to enlarger or other apparatus. (2) Improved double scale on dial has large, clear divisions and numbers; outer scale for setting time interval, and on which large white pointer is moved to desired time setting; inner scale with added red pointer moves counterclockwise from set point to zero and permits accurate determination of elapsed time.—*Industrial Timer Corp., 117 Edison Place, Newark 5, N. J.*

Foot Switch

New "Time-O-Lite" foot switch has many and varied uses, not only on instrument-shop machine tools, photographic enlargers,

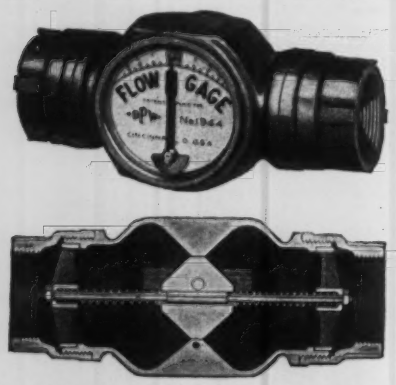


printers and safelites, but in inspection and testing where hands must be free. Any motor-driven equipment up to one horsepower may be controlled. A neon pilot light on foot pedal, inside switch, not strong enough to fog photographic paper, shows in the dark where the pedal is—"just step on the light." No bolting or screwing to the

floor: switch has a non-skid base. It operates on any a-c. circuit, incorporates a heavy-duty snap-action, single-pole double-throw switch. Silver contacts are used throughout. Two black outlets, each with 1500-watt capacity (total 3,000 watts), operate electrical equipment when pedal is depressed. One red outlet (1500 watt capacity) turns electric equipment off when pedal is depressed.—*Industrial Timer Corp., 117 Edison Place, Newark 5, N. J.*

Flow-rate Indicator

New "Magnetic Flow Gage" for liquids has neither front nor back for it is provided with two faces or dials. Functionally,

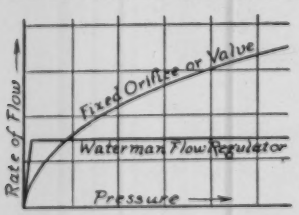


too, it is symmetrical, for it operates in either direction of flow. Operating principle is apparent from longitudinal section: a suitably-shaped aluminum plunger capable of sliding an axial bronze shaft is normally held by two phosphor-bronze coil springs in mid-position of "neutral" where it fits (with just enough clearance to prevent sticking) into the throat of meter body. Flow of liquid causes it to move, against force of one spring, until annular area between plunger and meter body is sufficient for balance of hydraulic and elastic forces. Plunger carries a cylindrical magnet (see small circle above center in sectional view) which simultaneously actuates both indicator hands through walls of meter body, which is of non-magnetic material. "Magnetic Flow Gage" is available in ½", ¾", 1", 1¼", 1½" and 2" pipe sizes. Pressure drop is said to be "extremely low" by reason of streamline contours of body and plunger.—*The Ohio Pattern Works & Foundry Co., 2735 Colerain Ave., Cincinnati, Ohio.*

Flow-rate Limiter

New "Waterman Flow Regulator" holds constant (to 5%) the rate of flow of fluids at any desired predetermined amount, re-

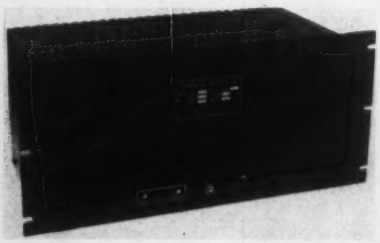
gardless of variations in applied pressure or work resistance, by employing a calibrated orifice in a floating piston whose movement is resisted by a spring. Predetermined rate



of flow moves piston, throttling escape ports. Any momentary rate of flow through the orifice in excess of predetermined amount causes piston to increase throttling, correcting rate of flow. Conversely, any momentary decrease in flow causes piston to decrease throttling, thus holding flow rate constant. Device is available in ¼", ⅜", ½" and ¾" pipe sizes; is smaller and far less expensive than elaborate regulators; permits close control of speed of hydraulic power devices and insures them against sudden release of hydraulic pressure. NOTE: In some applications, it is desirable to have rate of flow vary *with* pressure. Company can furnish requisite valves; construction, etc., depend upon individual requirements.—*Waterman Engineering Co., —721 Custer Avenue, Evanston, Ill.*

A-c. Voltage Regulator

New "Model 250S" a-c. voltage regulator is designed for instrument calibration and other exacting applications, providing con-



stant voltage, current or power (250-va. max. load) with 0.2% regulation accuracy when input varies between 95 and 130 volts; and exceptionally high purity of output wave-form (less than 5% harmonic content guaranteed in regular models, less than 2% in special models). Circuit is sketched in

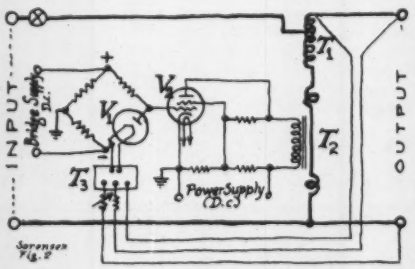


Fig. 2: Impedance of saturable-core reactor T_2 determines proportion of input voltage impressed across autotransformer T_1; this impedance is varied to restore output voltage to set value; T_3 and V_1 control reactor impedance by varying plate current of V_2 through saturating winding. Announcement mentions availability of various models with capacities ranging from 25 va. to 15 kva. —*Sorenson and Company, Inc., Stamford, Conn.*

CO_2 and Oxygen Test Set

New "Duplex Fyrite Test Set" comprises two separate portable indicators, one for direct CO_2 analysis, the other for direct oxygen analysis. Instruments are packed in a

carrying case together with aspirator and rubber hose for connecting either to desired sampling point. Both instruments employ chemical absorption principle, therefore give readings independent of voltage, humidity, temperature or atmospheric pressure. Operation: Sample is pumped into oxygen indicator by squeezing aspirator about a dozen times. Indicator is then turned bottom-side up and back again, causing absorbing fluid to mix with sample. Absorption of oxygen creates a suction which draws absorbing fluid up into graduated tube; level of fluid column shows percentage of oxygen which can be read directly. CO_2 tests are made by the same method, using the CO_2 indicator. Complete test with either instrument can be made in less than one minute with an accuracy of 0.5% O_2 or CO_2.—*Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Penna.*

Scanner for X-ray Inspection Equipment

New x-ray scanner is an industrial accessory for use with "Searchray 150" x-ray units (see Fig. 1). It overcomes distortion

Fig. 1

and displacement of conventional methods of x-ray image recording. Unlike light x-rays cannot be focused to give a parallel beam: they diverge to produce inaccuracies depending on relationship of film area to x-ray source. Scanner unit is 32" long, 14" wide and 16" high, consists of a motor-driven table on which specimen and film move beneath an adjustable slit through which the x-rays pass. (See Fig 2.) Table

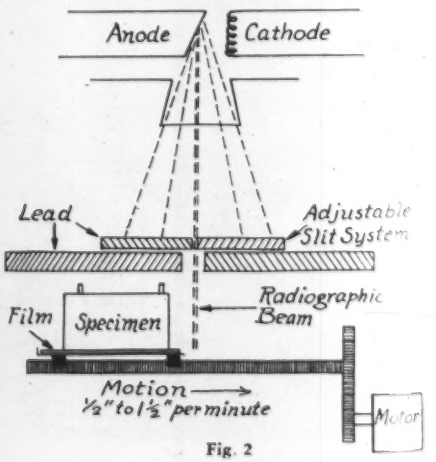


Fig. 2

TO BE PUBLISHED NEXT JULY

The 1946 Instruments Index

The only double-purpose directory of sources of supply of

MEASURING INSTRUMENTS

TESTING INSTRUMENTS

TESTING MACHINES, ETC.

METERS (FLUID, ELECTRICITY, ETC.)

GAGES, CALIPERS, ETC.

AUTOMATIC CONTROLLERS, GOVERNORS, ETC.

CONTROL VALVES

POWER UNITS, SERVOS, ETC.

TIMEPIECES, CLOCKWORKS, ETC.

RELAYS, BREAKERS, ETC.

INSPECTION EQUIPMENTS, ETC.

TELEMETERING SYSTEMS, ETC.

PHOTOELECTRIC ACCESSORIES

ELECTRONIC ACCESSORIES

OPTICAL ACCESSORIES

This Announcement is of interest to two groups:

INSTRUMENT USERS: Be sure to make your reservation now—in the only way, namely, by subscribing to *Instruments* or by renewing your subscription before July.

MANUFACTURERS: Bear in mind that the listings are free and without strings. The Instruments Publishing Company WANTS to make this first post-war issue complete and will spare no efforts to make it so. Before the war this involved making out and scientifically classifying fifty thousand cards; this time the work will be much greater. BUT every one of the hundreds of thousands of "little bits" of information comes from you. Therefore, send NOW for the forms to be used in making easy your job of supplying all these data.

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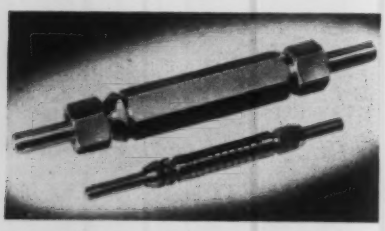
speed can be adjusted to suit application. Scanner precisely records geometric relationship of integrated components and spacings of segmented specimens, thereby contributing uniquely to quality control in manufacture of vacuum tubes, capacitors, switchgear, instruments, storage batteries, or any precision assembly where space measurements are desirable after parts are integrated. When fine-grain x-ray film is used, enlargements may be made for more accurate determination of element position and condition. This can serve to check component changes after certain periods of service. Scanner may also be applied to determine accurately the unknown thickness of material and to study intergranular structure of metals and plastics.—*North American Philips Company, Inc., 100 East 42nd Street, New York 17, N. Y.*

Reversible-wire-type Plug Gages

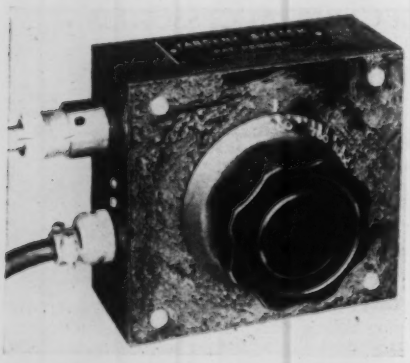
New line of reversible wire type plug gages utilize Carboloy cemented carbides, are available in a size range from 0.025" to 0.375" and are made to Class XX and X



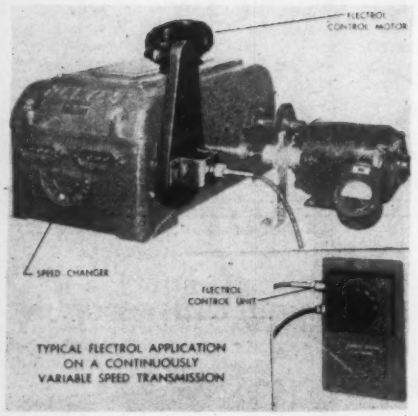
tolerances. Life of gaging members is said to be increased to at least fifty times that of those made of steel; users can disregard usual allowance for wear. Two styles of handle, both of collet type construction, are supplied. Flexible all-metal handle supplied for sizes up to 3/16" reduces hazard of breakage of members due to accident or rough handling.—*Lincoln Park Industries, 1719 Ferris Avenue, Lincoln Park 25, Mich.*

Remote-control System for Speed Controllers

New "Flectrol" system applied to commercial speed changers provides finger-tip remote control of speed. Dial can be set instantaneously to any desired speed and



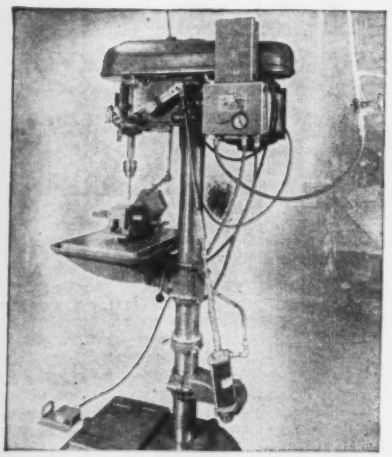
speed changer will follow as fast as the electric servomotor can drive the speed-adjusting screw. "Flectrol" gives precise indication of speed to operator. Dial can be calibrated in rpm., fpm., gph., etc. No other speed indicating devices are required. Any speed within range of changer can be selected with an accuracy of better than 2%. In operation, "Flectrol" controls rotation of small motor used to adjust pulleys or gears of speed changer. Rotation of speed-selector dial causes this motor to drive adjusting screw until output speed of controlled device corresponds to speed selected on dial. Illustration shows the "Flectrol" applied to a Reeves size "OO" horizontal enclosed speed changer. System is applicable to new or existing equipment of


FLECTROL CONTROL MOTOR
SPEED CHANGER
FLECTROL CONTROL UNIT
TYPICAL FLECTROL APPLICATION ON A CONTINUOUSLY VARIABLE SPEED TRANSMISSION

any type. It is available to all manufacturers and users of speed-changing equipment; can also be built in or added to motor-operated valves, machine tools, printing presses, conveyors, etc.—*Yardeny Laboratories, Inc., 105 Chambers Street, New York 7, N. Y.*

Automatic Controller for Machine Tools

New low-voltage (24V) "Electro-Air Control" permits conversion of standard machine tools and fixtures to automatic or semi-automatic production units by pneu-



matic control of machine or fixing movement. It may be used with any standard air cylinder and can be furnished to provide either single- or multiple-cycle control with addition of cycle timing, hesitation limit switches, etc., to perform a wide variety of operations such as automatic drilling, tapping, milling, indexing, holding, etc., etc. Advantages claimed for new control are: more compact design, which permits mounting anywhere on the machine without hindering operator movement or vision; absence of close-fitting ports or valves, which may tend to wear after long periods of service; low voltage (24 volts) employed reduces accident hazard and assures longer life of electrical units; easy and quick installation anywhere on any machine or fixture with wide control of cylinder stroke; accurate, rapid control of any push or pull motion provided by high-speed action of solenoid-operated needle valves. Pressure selection over a wide range is fast and accurate to provide exact pressure selection for the job and assure economy in the use of air power. Basic "Electro-Air" control units consist of a step-down transformer (115-220 v.ac to 24v). En bloc (manifold type) solenoid valves, pressure regulator, needle valves and armature.—*Electro-Air Devices Co., 2811 W. Fletcher St., Chicago, Illinois.*

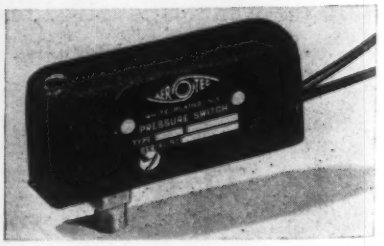
Automatic Contour Control for Machine Tools

New and greatly simplified "Duplicating Attachment" for machine tools, like maker's original contour control (see *Instruments*, May 1944, page 256) is a combined air and hydraulic system which may be attached to engine lathes, turret lathes or vertical boring mills to produce workpieces with contours which exactly correspond to a thin metal templet or master part. Simplification has been achieved by applying a single hydraulic power cylinder to the lathe compound, which is usually set at 45° to longitudinal axis of work. When mounted at this angle and used in conjunction with stan-

dard longitudinal feed, single power cylinder controls both longitudinal and in-out tool motion. New Attachment in no way hinders normal use of machine tool. Standard controls for speeds, feeds and depth of cut function equally well with or without Attachment. Duplicating Attachment is said to provide automatic sizing of tapers and radii and to obviate need of taking numerous repetitive measurements. After machine operator has made initial setup and tool adjustment, no further attention is required on his part other than to load and unload machine. Step shafts, mandrels, punches, dies, valve plugs, impellers, shells, forming rolls and bottle molds are typical of work on which Duplicating Attachment may be used to advantage. It is equally well suited for turning, boring or facing and may be applied to large or small machine tools. In the case of step shafts, all diameters, tapers, shoulders and undercuts usually may be turned in a single cut.—*Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, 10, Ohio.*

Pressure Switches

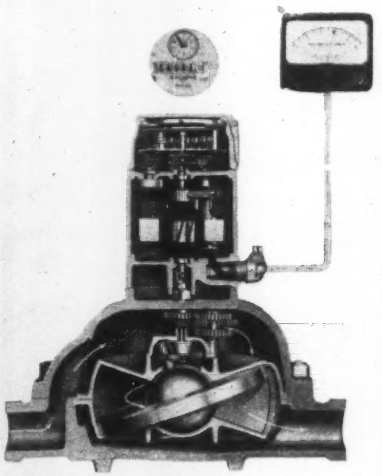
New "M-500," "M-600" and "M-700" switches for either pressure or vacuum up to 200 lbs./in.² weigh 8 oz., are designed for control of liquids or gases that will not corrode brass, in such applications as compressors, pumps and carbonated-beverage equipment. Switches are rated at 10 amps. on 110-volt a.c. Type "M-500" (illustrated) has an externally adjustable range with a fixed differential. "M-600" can be reset manually from the outside. "M-700" has an



adjustable differential. Contact arrangement in the first two can be specified as normally-closed, normally-open, or double-throw; third design is available only with normally-open contacts. Pressure connection is by means of 1/8" pipe nipple.—*Aerotec Co., White Plains, N. Y.*

Totalizing and Remote-indicating Flowmeter

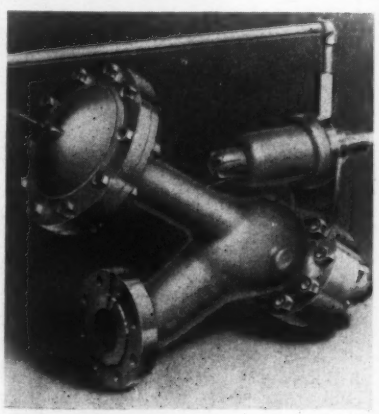
New "Veriflow Meter," for indicating and totalizing various liquids used in industry, indicates rate of flow at a point remote



from where meter is installed, by means of a transmitting generator mounted on top of the nutating-disk primary element, the same shaft operating generator and totalizing register. No external source of electricity is required: indicator measures output of generator and is calibrated in terms of rate of liquid flow through meter body. Indicator scale can be calibrated to read in any values of flow desired such as g.p.m. Among applications of new meter are indicating and totalizing flow of oil, testing hydraulically-operated mechanisms, flow of water in chemicals in continuous manufacturing processes, flow of fuel oil to oil burners, flow of a heating or cooling liquid, blending of two or more liquids (proportioning), etc. Some of the more unusual liquids that can be successfully measured by new meter are lacquer, tar, molasses, chocolate, rosin, soap, starch solution, whey, asphalt emulsions, paint, and varnish.—*The Hays Corporation, Michigan City, Indiana.*

Back-pressure, Relief and Stack Valve

New "S-FLO Valve" is designed for maximum flow and freedom from freezing. Its free-flow characteristic is attributed to an unusually straight flow, resulting from a 30° S-pattern valve body design, which elimin-

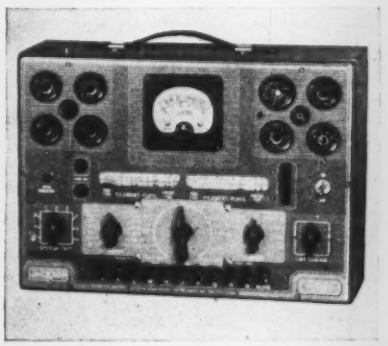


ALWAYS ROOM FOR ONE MORE

The unusually flexible switching system in your Jackson Dynamic Tube Tester is designed to check new tubes for receivers as they come out. New roll charts supplied when necessary. Spare socket positions are also provided.

MODEL 636 DYNAMIC TUBE TESTER

with built-in rotary tube chart



"Dynamic" Method of Test—Makes a better test on every tube. The "Dynamic" method is more accurate, frequently finding poor tubes which might pass for good in ordinary testers.

New High-Voltage Power Supply is a feature of this tester. By testing tubes at higher plate voltages (over 200 V. for some types), more accurate results are obtained.

Tests All Tubes—ALL of the popular receiving types and television amplifiers, including BAMTAMS—LOCTALS—SINGLE ENDED—HIGH VOLTAGE FILAMENT TYPES AND MINIATURES. Provision for many more. The tester is protected against obsolescence in every possible feature.

Roll Chart tube index—simplifies correct settings.

Full Range Filament Selections—From ¾ V. to 115 V. Selector marked directly in volts. This feature eliminates guess work and helps operator to avoid mistakes.

Most Improved Type of Switching System—Spare circuits and switch positions provided for future use. Two "spare" socket positions.

Noise Test jacks are provided for audible test of possible tube noise.

Portable Model: Grey leatherette case, 14" long x 12" x 5½". Weight: 11 lbs. Hinged lid removable.

Bench Model: Welded steel cabinet, 13" long x 9½" x 5½". Weight: 10 lbs. Rubber bumpers on base and back.

JACKSON

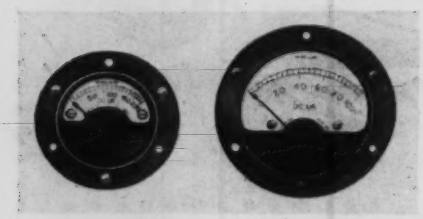
Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

ates turbulence. Uniformly even distribution of inlet flow plus direct downstream discharge and flow expansion, minimize wire-drawing and cutting action. Capacity is equivalent to conventional double-seated globe valves, yet single-seated valve and pilot construction is employed to insure positive tight shut-off with no leakage or seepage to freeze. Packing glands or stuffing boxes are eliminated. Being entirely self-contained and self-operating, units freely function on line fluid at flow line pressures, thereby obviating any need for secondary pressure reductions. Control accuracy is said to be greatly in excess of normal requirements.—*Grove Regulator Co., 6609 Green St., Oakland 8, Calif.*

Miniature Electrical Instruments

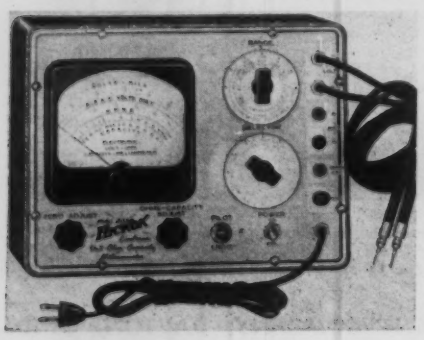
New "Model 102" (left) and "Model 152" (right) electrical indicating instruments feature a "peak-precision movement which is the smallest and lightest available today."



Developed to meet the AWS in every constructional and operational detail, this 1"-diam. moving-coil element does not depart from conventional operation. Accuracy is 2% of full-scale deflection at any point. Scales are lithographed on metal in 15-, 20-, or 25-line rulings, are sharply defined and easy to read. Use of an anodized aluminum case of sturdy and simplified construction is said to make it possible to offer substantial savings to user. "Model 102" mounts through a 1" opening, and is available in d-c. ranges from 0-100 microamperes through 0-10 milliamperes, and 0-50 millivolts. (External accessories for other ranges.) "Model 152" mounts through a 1½" opening and is available self-contained in all standard d-c. ranges; also in rectifier and thermocouple-type instrument.—*Instrument Div., The MB Mfg. Co., Inc., 331 State St., New Haven 11, Conn.*

Multiple-range Electrical Instrument

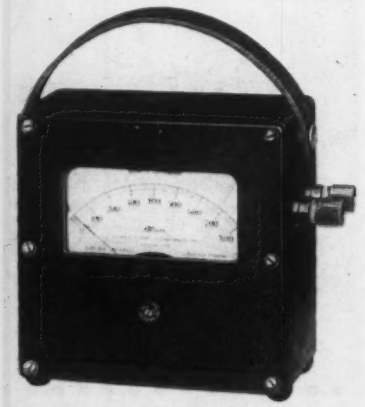
New "Model 203 Electronic Volt-ohm-capacitance-milliammeter" is designed to perform more functions than most volt-ohm-milliammeters. It accurately measures wide ranges of capacitance, resistance, and inductance as well as volts and amperes. A high-input impedance prevents loading when making voltage measurements. Electronic ohmmeter circuit permits measurements from 1.0 ohm to 10,000 megohms. Capacitance measuring circuit utilizes low voltage for measurements. Damage due to overload in voltage measurements is made impossible. Greater accuracy in a-c. measurements at frequencies over 5 megacycles is possible. Power supply required: 105-125-volt 50-70-cycle a-c. (other voltages and frequences available by special request).



Power consumption: 20 watts at 115 volts. Indicating instrument is "Type S44A" with 350-ma. sensitivity.—*Hickok Electrical Instrument Co., 10519 Dupont Avenue, Cleveland 8, Ohio.*

Portable Pyrometer

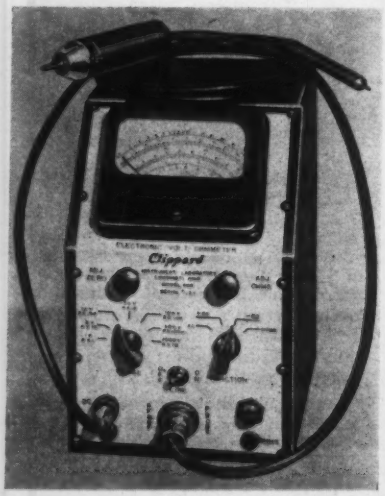
New "Type 1500 Portable Pyrometer," for laboratory and general industrial uses, is a compact, light-weight pyrometer. Electrical-instrument movement is "Alnor" dou-



ble-air-gap type with Alnico magnet. Case is heavy-gage sheet steel, providing magnetic shielding, so that "Type 1500" may be used on steel top table, near other magnetic instruments, or in strong alternating fields, without suffering unpredictable errors. "Type 1500" is available as a single-circuit pyrometer with a choice of ten scale ranges, 0-400 to 0-3000°F. and as a double- or triple-range instrument built to order with scales as specified. Centigrade scales can be furnished.—*Illinois Testing Laboratories, Inc., 420 North La Salle Street, Chicago 10, Illinois.*

Volt-ohmmeter

New "Model 406 Electronic Volt-Ohmmeter" features extreme range and a new bridge type circuit fully balanced through



three stages for maximum stability and accuracy. It covers every a-c., d-c., af., if., rf. and uhf. potential and resistance range likely to be required in the testing or repair of present and future radio, electronic, FM and television equipment. Full-scale sensitivity of 0-1, 0-10, 0-30, 0-100, 0-300 and 0-1000 volts a.c., 0-10 0-30, 0-100, 0-300 and 0-1000 volts a.c. and d.c., 0-1000 megohms in seven ranges with ample overlap and a db scale of—20 to + 51 are provided on a 200-ma. d'Arsonval type indicator. Hand-finished quartered oak case has folding [illegible] carrying handle. Detachable 36" d-c. [illegible] ground cable, ohms probe and fused [illegible] supply cable are also standard equipment. Input impedance is less than 7 mm[illegible] megohms a.c., 28 megohms d.c., assuring accuracy of readings through all ranges with minimum circuit disturbances. Instrument is calibrated to 2% accuracy in all ranges at plant with 5% accuracy guaranteed in field. Tube complement consists of one 6X[illegible]T rectifier and two 6SN7GT dual-purpose tubes chassis mounted, and one 6AL5 dual diode in shielded probe.—*Clippard Instrument Laboratory, 1440 Chase Avenue, Cincinnati 23, Ohio.*

D-c. Volt-ammeter

New "No. 5030" d-c. volt-ammeter is a portable instrument from which can be obtained forty interchangeable ranges, with

an accuracy of 0.5% of full-scale deflection. Sensitivity of volt ranges is 200 ohms per volt, and of amperage ranges 25 millivolts. Among features: Instrument is fully protected and guaranteed fool-proof against burning out movement or internal circuits, plus 4¾" linear scale with mirror to avoid parallax. Excessive currents cannot harm instrument in any way. Movement is protected by an electromagnetic relay in parallel with movement and doubly protected by a 1.5-amp. fuse in series with movement. Forty different ranges can be had by use of a shunt or resistor. For example, if full-scale reading is 250 volts, by twist of wrist one can have a full-scale of 150 volts, 7.5 volts, etc. Same applies to ampere ranges. Dust-proof Bakelite case. Dimensions 5⅝" × 4¾" × 1½"; weight 1½ lbs.—*Standard Science Supply Co., 1232 N. Paulina St., Chicago 22, Illinois.*

Multiple-purpose Tester

New "Model 456 Comprehensive Master Tester" makes available a two-hundred billion to one ratio in resistance measurements, is suitable for both laboratory and production testing, features an unusually large number of measurements and ranges, being equivalent to 61 individual single-range indicators, with eight types of testers

(1) insulation tester; (2) capacity meter; (3) ohmmeter; (4) a-c. voltmeter; (5) d-c. voltmeter; (6) a-c. ammeter; (7) d-c. ammeter; (8) impedance-inductance meter. A high degree of accuracy is combined with simplicity of operation. Tester is supplied with a set of high-voltage leads, a set of shielded test leads and a high frequency probe.—*Reiner Electronics Co., 152 West 25th St., New York.*

Multimeter

New "Model M45-11 Multimeter" is protected against damage from shock, vibration, water, dust and against burn-out by excessive or incorrect voltage applied to any

terminals. Movement is shock-mounted on spring suspension, balanced in all positions. Ohmmeter batteries are in separate sealed compartment for easy replacement. All exterior parts are metal or shatter-proof plastic: drawn aluminum case, aluminum panel $\frac{3}{16}$" thick, extremely rigid and finished in tough enamel. Metal parts inside and out are heavily plated or finished; wiring coated with inorganic varnish. Resistors, etc. are mechanically anchored independent of wiring. Instrument is suitable for service in mines, shipyards, etc. in all atmospheric conditions. Dimensions $13\frac{1}{8}$" × $11\frac{1}{2}$" × $5\frac{1}{2}$"; scale length $5\frac{1}{2}$". Ranges: d-c. volts, 6 ranges to 1000 volts at 20,000 ohms per volt; d-c. current, 8 ranges from 50 microamps to 100 amps.; a-c. volts, 6 ranges to 1000 volts; a-c. amperes, 6 ranges to 50 amps.; low ohms, 0-250; high ohms, 5 ranges to 10 megohms.—*Electronics, Inc., 915 Meridian St., South Pasadena, Calif.*

Radiofrequency Voltmeter

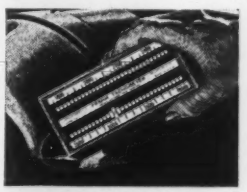
New "Model 304" Sensitive R. F. Voltmeter," a version of maker's standard "Model 300 Electronic Voltmeter," presents principal added feature of greater bandwidth, the high-frequency limit being extended to beyond 5 Mc. Adoption of probe type of input connection also assures greatest accuracy of indication at radio fre-

Look to **BIDDLE . . .**

For Precision Instruments

FOR MEASURING SPEED

Over the past 30 years we have been a source of supply for precision speed measuring instruments that have consistently demonstrated their superior quality, high accuracy and dependability in service. We now offer a variety of types and ranges of instruments for measuring rotational and surface speeds, and rates of vibration. We believe they will be helpful in the solution of some of your engineering problems. The following are typical:

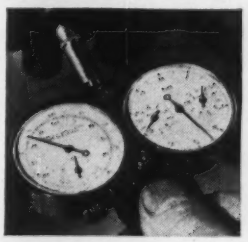


The FRAHM VIBRATING REED TACHOMETER *requires no contact with the rotating element and is unique for measuring speed of totally enclosed machines and other equipment where the end of the shaft is not accessible. The only mechanism is a set of accurately tuned steel reeds which vibrate by resonance according to the speed of the machine on which the instrument is held. For hand use in servicing, installation and maintenance work; also built in types for permanent mounting. Various ranges available from 900 up to 100,000 rpm. Used also and in the same way for measuring rates of vibration.*

Write for descriptive Bulletin 1590-I.

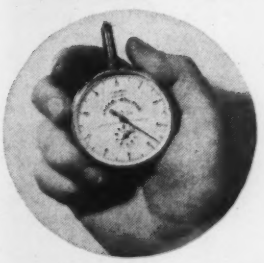
JAGABI PRECISION HAND TACHOMETER. *Five ranges in one instrument. Simply rotate the barrel head to change to any one of the five ranges—60-240, 200-800, 600-2400, 2000-8000, 6000-24000 rpm. Measures rpm and fpm by direct pointer deflection . . . fly-ball governor principle . . . large, easy-reading dial with two scales nearly 6½" long. . . . Accurate to within one scale division. . . . Independent of direction of rotation. . . . Supplied complete with case and accessories.*

Write for descriptive Bulletin 1800-I.



JAGABI HAND TACHOSCOPE. *A combined speed counter and stop watch with synchronized start and stop mechanism for measuring average speeds and constant rates of speed to a high degree of accuracy. Used for routine tests as well as for checking other speed-measuring instruments up to 20,000 rpm. Can be used also for measuring linear or peripheral speeds. Stop watch can be used independently. Supplied complete with case and accessories.*

Write for descriptive Bulletin 1790-I.



The JAGABI SPEED INDICATOR *is a watch size speed measuring device which adds up the number of revolutions over a period of three (or six) seconds and shows the revolutions per minute without any calculations. Can also be used to measure feet per minute. Available in two models—for low speeds up to 2000 rpm and for all speeds up to 20,000 rpm. Accuracy well within one-half of one per cent.*

JAGABI HI-SPEED INDICATOR *(not shown). Chronometric type designed for extraordinarily high speeds, operating on the same principle as the Jagabi Speed Indicator. For speeds up to 100,000 rpm.*

Write for descriptive Bulletin 1505-I.

JAMES G. BIDDLE CO. • **1316 ARCH STREET PHILADELPHIA 7, PA.**

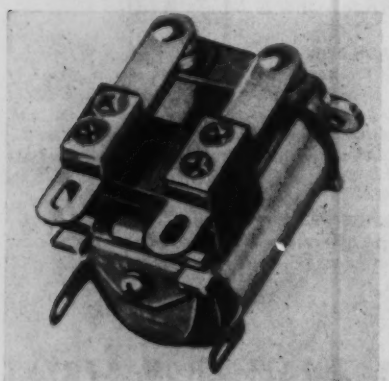
quences. New instrument is not intended to replace "Model 300" but meets need for a voltmeter capable of indicating millivolts in television and FM intermediate-frequency amplifier circuits, r-f. heating apparatus, carrier current systems, etc., wherever sensitivity and low shunting error are required. It does not possess degree of accuracy of its prototype. Extension of bandwidth has been accomplished by use of higher gain tubes and rearrangement of circuit components to reduce high-frequency losses. Amplifier output is separately available through a coaxial type connector, hence permitting visual observation of input wave on an oscilloscope as well as other applications for such a wide band amplifier. Full gain of this amplifier is approx. 500. Two multipliers are supplied so that instrument provides same range as standard "Model 300," namely 0.001 to 100 volts. These multipliers are compact units which fit snugly over probe terminals and simply extend length of probe by 1¼". Additional units will be made available in future which will further raise voltage limit. These will also provide progressive reduction of shunting loss as input capacity becomes less for each upward extension of voltage range.—*Ballantine Laboratories, Inc., Boonton, N. J.*

Thermocouple Type Vacuum Gage

New gas-pressure-measuring tube contains hot junction of a thermocouple element centered on a filament heater, utilizes thermal-conductivity principle, permits measuring pressures of 10^{-1} to 10^{-5} mm. to ±5% accuracy. Applications include laboratory use as a pressure gage and leak detector in evacuating apparatus. Operated in a 3-volt battery and resistance circuit, it may be sealed directly into evacuating apparatus by means of tubulation provided on top of bulb. Direct measurement may be made with a 0-250 microammeter which may be calibrated for each gas measured. Maximum accuracy is assured by shielding from sources of radiant heat and air currents. Tube is 4-7/16" long over pins and 1-9/16" maximum bulb diameter, is supplied with small 4-pin base and may be operated in any position. Maximum value electrical ratings are: filament resistance, 3.0 ohms; thermocouple resistance, 5.0 ohms; filament current, 125 milliamperes; thermocouple current, 250 microamperes.—*Electronics Div., Sylvania Electric Products Inc., Boston 15, Mass.*

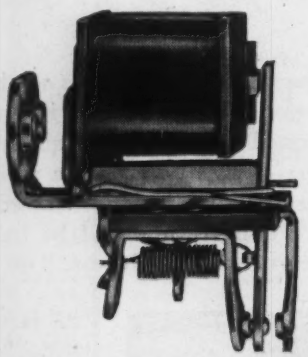
Control Relay

New "Type CR" control relay combines compactness and light weight, is claimed to be more efficient on precision application in industrial and special control circuits than larger and heavier power relays. Contacts are unusually large: up to ¼" diam. and are generally supplied in silver although alloy contacts are obtainable. Extra-heavy pressure permits power switching said to be heretofore possible only with much larger relays. "CR" is available in two, three and four pole combinations, and if desired, hermetically sealed. Molded Bakelite is used throughout for insulation. Structural rigidity is assured by use of a formed steel base. Contact rating with ¼" silver contacts is 15 amperes at 24 volts d.c. or 110 volts a.c., non-inductive. Single pole "CR" weighs 3 ounces, is 1 33/64" high, 1 3/32" wide and 1 25/32" long. Various contact combinations are available in all "CR" models.—*Allied Control Company, Inc., 2 East End Avenue, New York 21, N. Y.*



Midget Sensitive Relays

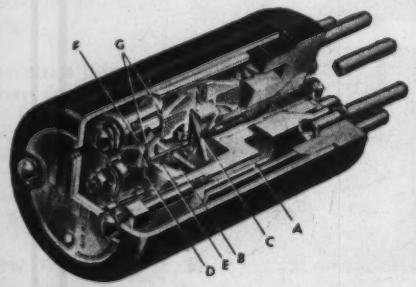
New "Series 13" line of midget relays feature 0.035-watt sensitivity in a compact 1-ounce unit. Relay is designed for low current operation under conditions where space



and weight are limited. A balanced armature construction assures stability at high-speed operation in all positions. Coil will safely stand 1 watt without over-heating. Contacts are single-pole double-throw and are rated to carry ¼ amp. 110 volts a.c. non-inductive load. Approx. dimensions: 1-½" long. 1-⅛" wide and 1" high overall. A coil may be selected for any d-c. input voltage between 0.04 and 40 volts.—*Kurman Electric Co., 35-18 37th St., Long Island City 1, N. Y.*

Magnetic Relay

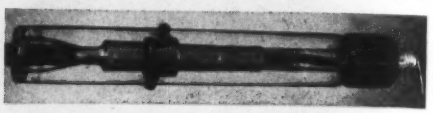
New "Model 103 Sensitive Magnetic Relay" is designed for operation on thermocouple and photocell outputs and in equip-



ment requiring compactness, light weight, and dependability under vibration. It is particularly useful as a polarized relay in vacuum-tube circuits, in balanced circuits, and in applications requiring pull-in and drop-out at essentially the same current or voltage. In extremely delicate control circuits, it is said, this relay can be used to help "shrink" mechanical design by eliminating intermediate amplification. Mechanism is protected against weather and dust by a gasketed metal cover and it is balanced to allow operation in any position. Movement is moving-magnet stationary-coils type, permitting use of bobbin-wound coils containing more wire than usual and thus giving wide latitude in selection of resistance values to match associated circuits. Coils may be connected in series, or differentially so that relay will operate on difference between currents in two coils. Contacts handle ⅓ ampere in a non-inductive load circuit; and provide either s-p.s-t. or s-p.d.t. switching. Operating power is normally about 10 microwatts although for some circuit applications operation may be secured with less than 1 microwatt. Coils will safely dissipate 2 watts; construction will withstand substantial overloads without damage when used as a simply relay. Magnetic system is enclosed in highly-permeable metal shield (A) which protects it from stray external magnetic fields. Rotor (B), pivoted in spring-loaded jewel bearings, has small Alnico vane (C) at its lower end and, at its upper end, hairspring (D), balance cross with weights (E), and platinum-iridium contact arm (F). Magnet vane is positioned between two parallel stationary coils (G) whose magnetic fields are coincident. Aluminum cover is mounted on a standard small seven-pin radio tube base. Diameter of unit is 1¼"; seated height 2¼"; weight 0.15 lb.—*Instrument Div., Thomas A. Edison, Inc., West Orange, N. J.*

X-ray Diffraction Tube with Chromium Target

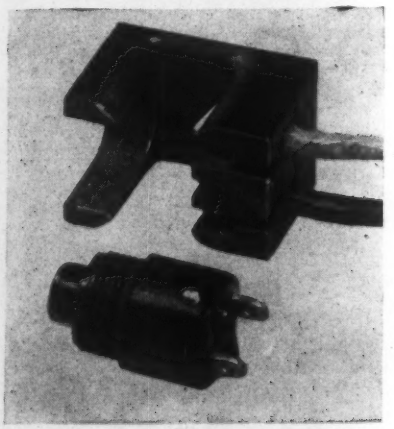
New chromium-target x-ray diffraction tube, with chromium electroplated on a copper backing has a rating as high as



that of copper-target tubes. Old-type chromium-target tube was rated at one-fourth the heat input possible with copper, while new model makes chromium competitive with pure copper in efficiency. Use of new type is indicated in experiments requiring high resolution provided by chromium with its characteristic longer wave-length radiation. New target construction increases heat loading by presenting grain structure of anode material in a dense condition at right angles to surface. This extends useful life of tube: hitherto, heat caused grain growth in anode, resulting in roughening of surface and thereby tending to reduce x-ray output. Manufacturer now produces and stocks diffraction tubes with seven different types of targets; tungsten, molybdenum, copper, nickel, cobalt, iron and chromium. Others, such as silver and manganese, can be supplied on special order. Development is proceeding on titanium and germanium; various alloy targets built for special purposes.—*General Electric X-Ray Corp., 175 W. Jackson Blvd., Chicago 4, Illinois.*

Renewable Switch

New renewable switch is an adaptation of unusually small switch illustrated and described in *Instruments*, Aug. 1945, pages



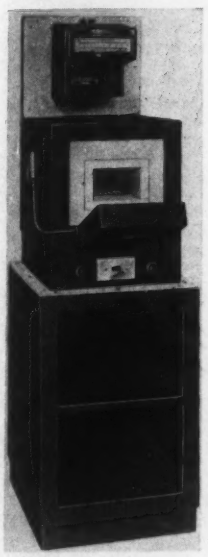
588-590. As a standard item it can be used in a single-hole mounting. As renewable type, switch studs slide between two contact bars in new cradle; front part slides down through slot in front part of cradle. Cradle itself is attached to any flat surface by countersunk screws. Entire device is a little over 1" long and ¾" high. At present, only s-p.s-t. switches (either n-o. or n-c.) are available in new renewable type.—*Robert Hetherington & Son, Inc., Sharon Hill, Pa.*

Linear Voltage-dividing Resistors

New line of wire-wound linear voltage-dividing resistors consists of three models giving performance accuracies said to be hitherto unobtainable in a single-turn unit: 0.05% in largest (5" diameter) and 0.15% in smallest (2"). Accuracy life exceeds 1,000,000 cycles of operation. Rotation is from 352° to 357°, leaving a maximum unwound sector of 8° in smallest size and 3° where maximum wound length is required. Torque is unusually low: less than one inch-ounce. New units are said to offer many possible applications in simplifying circuit designs for precise control, either when used singly or ganged on a common shaft.—*Fairchild Camera & Instrument Corp., Jamaica, N. Y.*

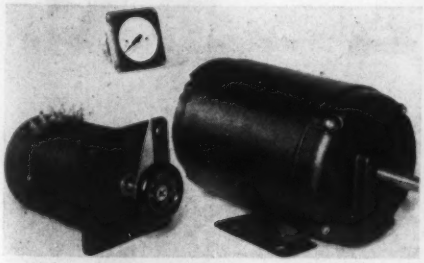
High-temperature Furnace

New "Hi-Temp" furnace is a small-capacity unit recommended for continuous operating temperatures up to 2200°F., intermittent to 2250°F. Available in floor and table models, both models furnished complete with automatic temperature control; two pilot lights (one indicating furnace operating; other indicating failure in heating elements); ready for operation by connecting line to outlet box. Operates on 110-volt a.c.; power consumption 2 kw. Inside dimensions (floor and table models): 5½" wide × 3⅝" high × 6" deep (3½" throat additional). O.D. of table model 18" wide × 32" high × 20½" deep. O. D. of floor model 18" wide × 63" high × 22" deep. Bottom of inside dimension to floor—41". Floor model is equipped with two steel shelves.—*K. H. Huppert Co., 6830 Cottage Grove Avenue, Chicago 37, Illinois.*



Remote-positioning and -indicating System

New d-c. positioning and indicating equipment which can be operated from any a-c. or d-c. line is announced for general industrial use wherever remote indication and control systems are employed: in oil fields, steel mills, steam or hydroelectric plants, and on shipboard. Specific uses include governor and generator field control



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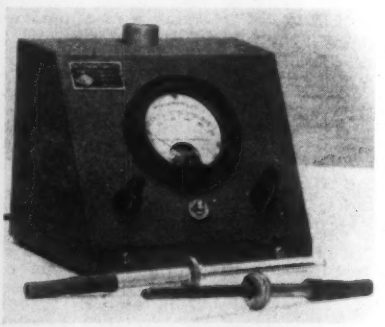
systems for multiple synchronized diesel-electric drives, master remote control for reversing mill motors, remote Ward-Leonard control systems for multiple diesel-electric power plant mobile units, and remote indication or control over mechanical, electrical or hydraulic devices such as level, pressure and flow indicators. Immediate receiver response without hunting or overshooting is said to be attained over entire operating range of system. Receiver is a positioning unit in which relative strength of magnetic fields of stator determines position that its permanent-magnet rotor will assume. Any change in this relationship of the field strength causes rotor to turn and assume position corresponding to new resultant of the two fields. Receiver torque is a function of displacement between rotor and magnetic axis of receiver. Transmitter, essentially a variable-resistance bridge operated manually or automatically, controls relative strength of receiver magnetic fields. Receiver and transmitter torques are independent and receiver torque required to move a device has no effect on transmitter. Transmitter is designed to operate any number of receivers within rated capacity at any specified d-c. voltage. Power requirements are essentially constant under all operating conditions. Overloading receiver beyond its torque rating cannot damage receiver or transmitter. System is mechanically simple in construction: only four leads are needed for each receiver and two power supply leads to transmitter on most applications. All devices are designed with overlapping characteristics to afford maximum interchangeability, and equipment can be readily modified to operate at any desired d-c. voltage. Six sizes now available range from five ounce-inches to 360 pound-inches approximate pullout torque, and with a small drip-type rectifier unit may be operated on alternating current.—*Allis-Chalmers Mfg. Co., Milwaukee, Wis.*

Smoke Meter

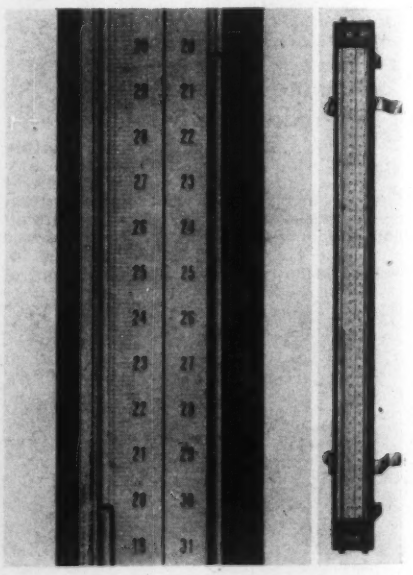
New "R. S. Smoke Meter," built to specifications of Institute of Cooking and Heating Appliance Manufacturers, is in principle a photoelectric soot density comparator. Operation is based on fact that the surface of a Pyrex glass rod placed across a stream of flue gas containing oil smoke will collect a deposit of soot which will be a function of proportion of smoke in flue gas when exposed under specified conditions. Amount of the smoke deposit can be measured by its attenuation of a beam of light through glass rod onto a photocell. Metal case, approx. 5½" × 5½" ×6½", houses a 15-watt lamp and a photo cell connected to an electrical indicating instrument. A light tube

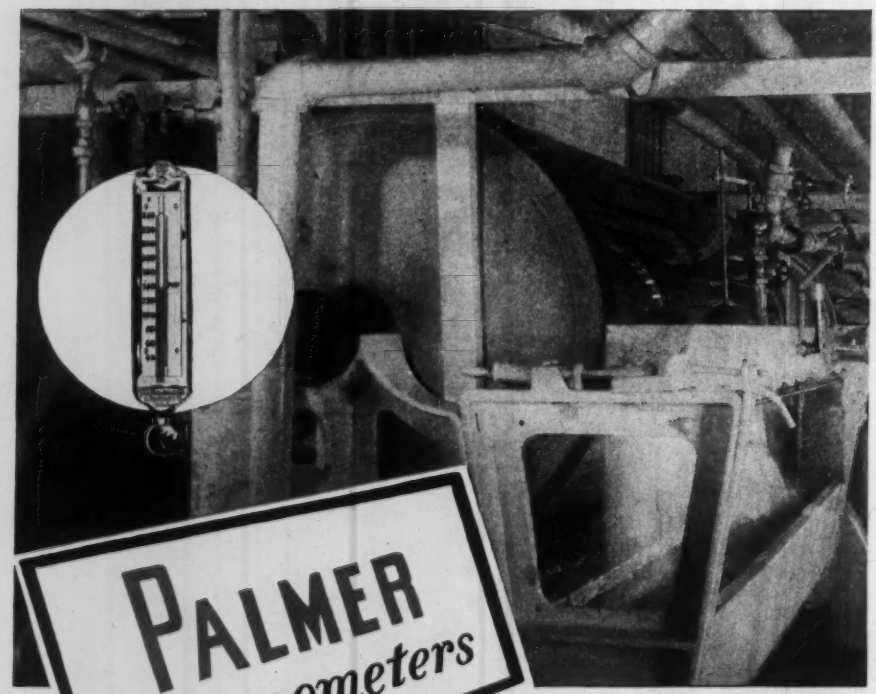


supports the Pyrex glass rod between the lamp and the photocell. A constant-voltage transformer maintains 110 V. on the lamp. Two adjusting knobs are provided in the indicator circuit. In operation, smoke meter is adjusted for "zero" reading with a dull black rod in light tube; then it is adjusted for "100" reading with a clean Pyrex glass rod in light tube. After this Pyrex rod has been exposed to the flue gases, it is replaced in the light tube and the meter will give a reading indicating the percent light transmitted.—*The Refinery Supply Co., 621 East Fourth Street, Tulsa, Okla.*

Two-tube Manometer

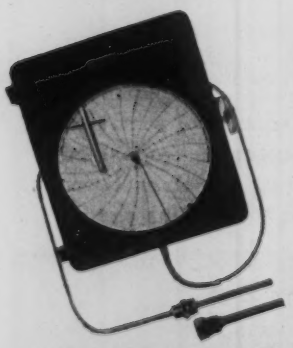
New "Model M-100 Dual Tube Manometer" consists of two separate manometer tubes in the same case—each tube with individual well. It enables operator to read high-range pressures, vacuums and differentials from floor level. Left tube has a scale increasing upward; right-tube a scale increasing downward; both are connected in parallel to the same pressure or vacuum system. Instrument is available in ranges





PALMER Thermometers

Help Maintain UNIFORM HIGH QUALITY in "CRISCO"



red reading mercury

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Palmer Thermometers were selected because of their extreme accuracy and their patented easy-to-read mercury column. Palmer Thermometers are ruggedly constructed, too, for long, dependable service.

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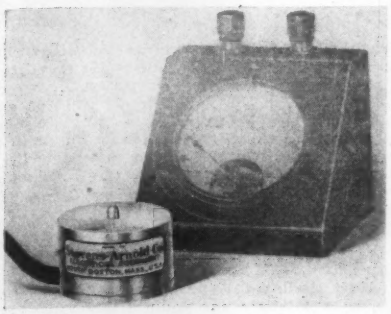
of 50" to 150", is said to be ideal as a calibrating standard manometer for checking flowmeters, pressure gages, etc. It is direct-reading. Since both tubes indicate the same reading, operator can choose more convenient one. New manometer is claimed to help avoid accidents because of its ease in reading from floor level and to save time and effort in reading.—*The Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio.*

Pressure and Deflection Pick-up

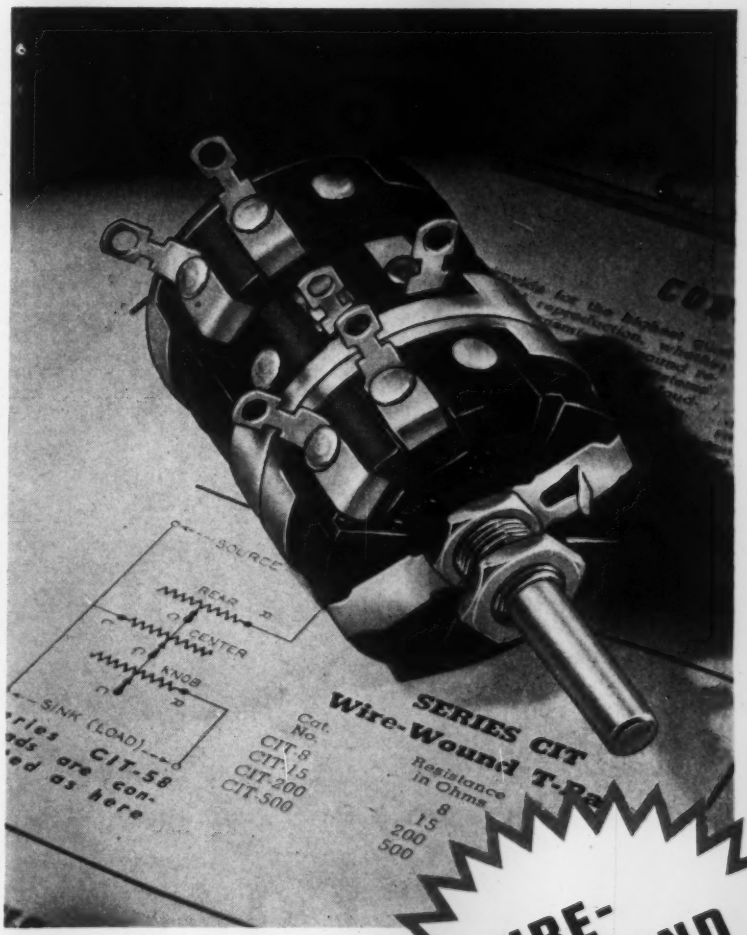
New Deflection Pick-up is a hermetically-sealed electrical unit which translates minute deflections or pressure variations, applied to its plunger, into linear changes in



its d-c. output voltage. Range is 0.0005" to 0.1" movement of plunger and reliable response up to 100 c.p.s. can be expected. New unit is said to depart from conventional practice without sacrificing reliability in that its output is 75 millivolts and its internal resistance less than 1 ohm, so that it may be connected directly to rugged, inexpensive and portable indicating instruments. Several pick-ups may be connected together in parallel. Combination of new pick-up and an inexpensive voltmeter gives the following results and remote indications are obtained at any distance: (1) Electric micrometer range 0.001" to 0.1"; (2) electrical measurements of force, acceleration and pressure; (3) electrical deflection gage. New unit may be used under unfavorable operating conditions, including heavy vibration, at temperatures up to 300°F. and may be submerged in water. Power supply may be 115 volts a.c. or battery (8, 12 or 24 volts). Results may be recorded on a continuous strip chart.—*Stevens-Arnold Co., 22 Elkins St., South Boston, Mass.*

Voltage Supply

New "Type D.S. 111 60 Cycle Decade Voltage Supply" furnishes a.c. potentials of laboratory accuracy for laboratory or production-line use in testing and calibration of a.c. instruments, vacuum-tube voltmeters or other circuits where a known source of a.c. voltage is required. It incorporates a precision transformer of the true isolating type with a primary tapped to adjust within 0.1 volt of line voltages from 100 to 132. Secondary is precision tapped to provide



WIRE-WOUND *Controls*

Series 58 rheostats and potentiometers, available in single, dual and triple section units (as here shown). Available with attached power switch.

★

Series 42 multiple-unit wire-wound controls, available in assemblies from 2 to 18 sections in tandem and operated by a single shaft.

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Series 43 midget wire-wound controls in single, dual and triple section units. Available with attached power switch.

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Series MH or the famous "Humdinger" extra-compact rheostat or potentiometer. Wire winding held in grooved fibre base. Body only 9/32" deep.

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★ You can entrust your wire-wound control problems to Clarostat, with complete confidence, because: (1) Clarostat has wire-winding experience second to none in the industry; (2) Clarostat has outstanding winding equipment designed, developed and built by its own engineers; (3) Clarostat spent two decades perfecting wire-wound rheostats and potentiometers; (4) Above all, Clarostat has an enviable reputation to maintain. Therefore, try Clarostat with those wire-wound control problems or requirements.

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CLAROSTAT *Controls and Resistors*

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

output voltages of 0 to 111 in 0.1-volt steps. A Weston "Model 476" indicator in the secondary circuit has a single red line on its scale to indicate proper primary voltage adjustment. When primary is adjusted to 100 volts, instrument may be used as a variable-ratio transformer provided input voltages do not exceed calibration settings. 1000-to-1, to 1-to-1 values, in steps of 0.001, are furnished in ranges up to 10,000 cycles. Output is conservatively rated at 30 va. as follows: 0.1 to 1 volt, 5 amperes permissible current, 0.01 to 11 volts, 2 amperes; 0.1 to 31 volts, 1 ampere; 0.1 to 111 volts, 0.3 amperes. Accuracy of 1% is guaranteed for voltage output and 0.25% for the ratios. Unit is mounted on Bakelite panel housed in a hand-finished quartered oak case. Terminals are standard ¾" laboratory-spacing banana pin jack binding post type. Detachable input cord contains 1 ampere fuse. Instrument is also supplied for 25-cycle operation and in 1 to 1110-volt output model.—*Clippard Instrument Laboratory, 1440 Chase Avenue, Cincinnati 23, Ohio.*

Yellow Light-polarizing Filter

New two-in-one camera filter permits both color correction and control of reflections for black-and-white photography. Like a standard yellow filter, it increases cloud-sky contrast and sharpens haze-covered horizons; like a standard polarizing filter, it permits reflection control and reveals surface texture and detail, while darkening the sky even further without darkening foreground greens and yellows. It is a sandwich of yellow plastic combined with a polarizer and laminated between glass disks of optical quality by a production technique developed during the war. Polarizing characteristic and yellow color work well together to darken blue skies and penetrate haze because the same process—scattering of light—that makes the sky blue and that gives haze its bluish tinge also creates polarized light. Filter factor of new yellow polarizing filter is between 4 and 5 for most standard films.—*Polaroid Corp., Cambridge 39, Mass.*

Stroke Counter with Over-travel Arm

New small, rugged non-reset stroke counter with built-in protection against over-travel of operating arm is announced. Op-

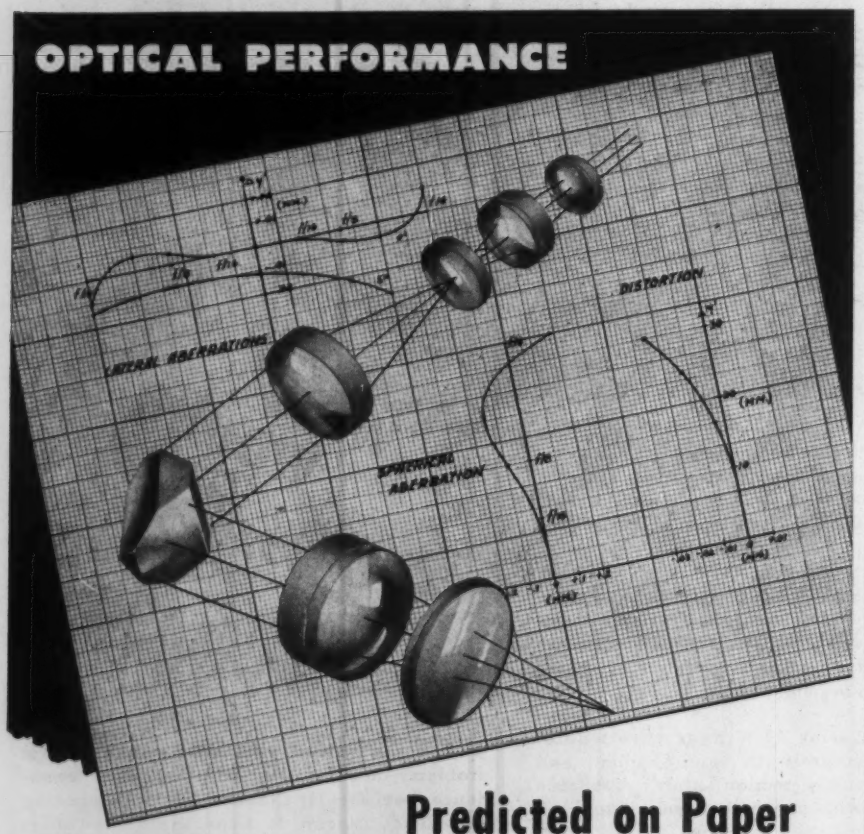
erating arm works against a coil spring which permits arm to continue beyond full stroke without injury to counter. Arm may be installed on either side of counter and set at any angle. Counter is completely enclosed in a tamper-proof case for built-in applications. The five large number wheels register to 99,999 and repeat.—*Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Illinois.*

Low-range Pressure Gage

New bellows type low-range pressure gage is suitable for indicating draft pressures or any low pressures of gases or liquids that are not corrosive to bronze, is recommended for use in gas plants. Pressure element is a self-draining bronze bellows with a phosphor-bronze calibration spring which is claimed to make an extremely sensitive and accurate gage. Adjustable stops protect bellows from excess pressure or vacuum. It is supplied in 4½" and 6" phenol cases with ¼" male pipe thread lower or back connection. "Type 1188 P" is supplied in pressure ranges from 10" of water up to 10 lbs. pressure; "Type 1188 V" in vacuum ranges from 10" of water up to 20" of mercury vacuum.—*Manning, Maxwell & Moore, Bridgeport, Conn.*

Pressure Transmitter

New "Autoflight Pressure Transmitter" consists of a bellows element in the pressure chamber coupled to an ultra-low-torque voltage-dividing resistor (see *Instruments*, June 1945, page 424), thereby providing a control or indicating voltage proportional to pressure upon bellows element. Variation



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Buffalo 15, New York

Manufacturers of the **SPENCER** *Scientific Instruments*

in pressure causes bellows to actuate resistor by means of a push-pull rod and rack-and-pinion. Instrument can be supplied in various differential or absolute pressure ranges from zero to 300 lbs./in.² absolute. Sensitivity of the pressure transmitter is ±0.5% and accuracy is ±2%—*Autoflight Instruments Div., G. M. Giannini & Co., 161 E. California St., Pasadena 5, Calif.*

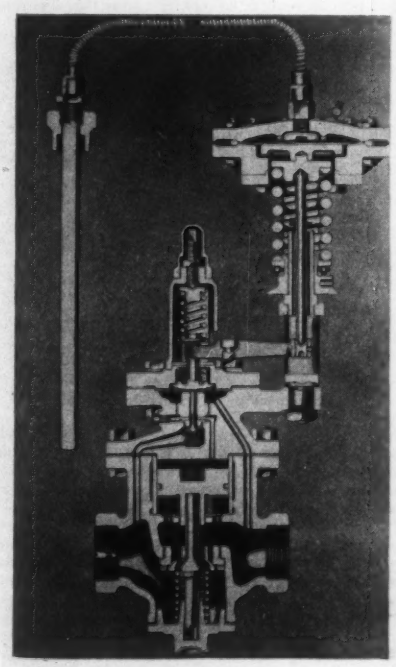
High-energy Capacitor for Speed Flash Photography

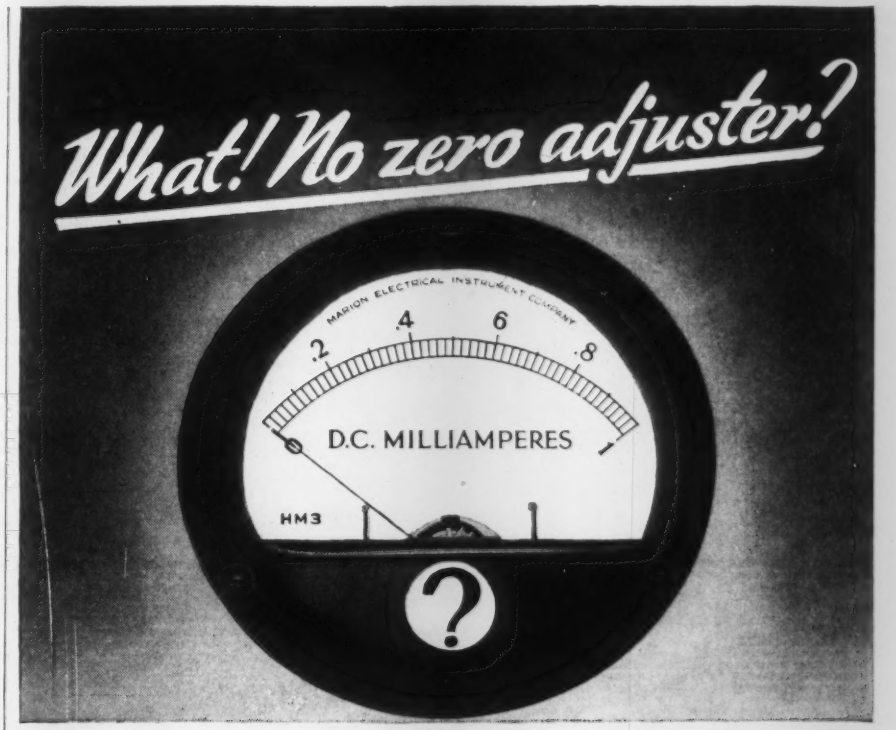
New "N-Erg-Y Capacitor" has energy storage capacity of 100 watt-seconds at a peak rating of 2500 volts d.c., is especially designed for use with portable speed-flash

units. Its dependability under diversified operating requirements is said to suit it to all types of indoor and outdoor service in modern super-speed photo-flash work. Hermetically-sealed steel case dimensions 6⅛"×4⅝"×3¾"; weight 6¼ pounds. Heavy-duty screw terminals on cup-type phenolic bushings, facilitate connection of large cables used to handle high instantaneous currents which, with this capacitor, may be as great as 1250 amperes. Expected life is at least 10,000 charge-discharge cycles at peak rating. Ability to hold peak for approx. twenty-four hours. Immediate delivery.—*Tobe Deutschmann Corp., Canton, Mass.*

Temperature Regulator with Pressure Compensation

New self-contained spring-loaded internal-pilot piston-operated temperature regulator for steam service features "Duo-Matic Control," whereby both accurate temperature regulation and pressure control are





This is the invariable first reaction of engineers and consumers when meeting Marion Glass-to-Metal Truly Hermetically Sealed Instruments face-to-face. Let us begin by saying that zero adjusters correct for mechanical changes in an instrument caused by drift of the hair springs, ageing of the moving system, and are often used to correct (but incorrectly) errors brought about by unbalance of the moving system. Marion "hermetics" eliminate the need for zero adjustment for the following reasons:

Drift-free Springs: Marion "hermetics" use special silvered beryllium copper hair springs which are essentially drift-free. And the instruments as a whole are thoroughly aged at 170° to 180° F for at least 48 hours, assuring permanent "set" to the components of the moving system. These factors permit overloads far in excess of normal specifications, without permanent zero shift of the instrument.

"Apologist for Error": When a panel instrument is overloaded and its pointer is slammed, re-setting with the zero adjuster *does not* correct the error caused by the unbalance of the moving system. It only apparently corrects this error, and conceals its magnitude. Slammed instruments should be repaired or replaced if stated accuracy is to be maintained, and not just covered up by that *apologist for error*, the zero adjuster.

Independent Tests . . . by private and governmental laboratories in the United States and Canada prove that Marion "hermetics" sustain zero setting under severe and continuous shock, vibration, temperature and humidity cycling. Maximum permanent zero shift recorded on any "hermetic" by any laboratory has been ½ of 1% after completion of any and all combinations of the foregoing tests.

Marion Glass-to-Metal Truly Hermetically Sealed 2½" and 3½" Electrical Indicating Instruments

Write for 12-page brochure

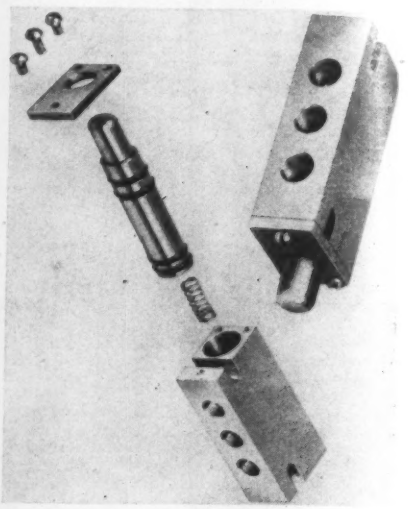
MARION ELECTRICAL INSTRUMENT CO.
MANCHESTER, NEW HAMPSHIRE
EXPORT DIVISION
458 BROADWAY · NEW YORK 13, N. Y., U. S. A.
CABLES: MORHANEX

IN CANADA: THE ASTRAL ELECTRIC COMPANY, SCARBORO BLUFFS, ONTARIO

said to be obtained simultaneously with a single regulator. Piping is thus simplified and installation costs materially reduced. New Regulator has 100°F. adjustable temperature range; is single-seated for positive dead-end control; is equipped with metal diaphragms; has no bellows or packing glands. All wearing parts are renewable. 100% interchangeability allows complete overhaul without removal from pipe line. Corrosion and wear resistance is obtained with the use of stainless steel hardened wearing parts. Vital parts are hardened to at least 500 Brinell. A vapor-pressure type thermostatic element acting through upper diaphragm and lever opposes pressure-limit spring and determines steam pressure delivered by regulator to heat exchanger. Manual compression of limit spring determines maximum outlet pressure and opens controlling valve admitting high-pressure steam from inlet body port to top of piston which opens main valve. Outlet steam pressure acting under steam diaphragm balances compression of limit spring, throttling control valve and limiting maximum outlet pressure. Temperature at which vapor pressure starts to oppose limit spring and decrease outlet steam pressure is set on adjusting spring. A temperature drop of 1°F. at bulb reduces vapor pressure, allowing limit spring to open control valve and deliver an increased steam pressure to heat exchanger. Therefore, outlet steam pressure is always directly proportional to the change in temperature at bulb and this pressure is automatically maintained regardless of volume of steam used by heater or variations in supply pressure.—*Leslie Co., 214 Delafield Ave., Lyndhurst, N. J.*

Pneumatic 3-way Pilot Valve

New "CVR Modernair" 3-way pilot valve, for use in application of controlled air power to machine tools, is designed to be used as a 3-way valve, normally either open or closed, or as a 2-way valve, normally open or closed. Installation as a 2-way pilot valve is accomplished by simply plugging one port. Length is 3¼" overall with the piston fully extended. Valve may be operated by hand, foot treadle or cam which may be part of a timed sequence of operations. It utilizes aircraft type packings on piston rod as bearing points (no metal-to-metal contact within valve). Valve is completely renewed by replacing four "O" ring packings. It is impossible for plunger to come out of housing during installation or operation. Another feature is that new unit is fully balanced, operating freely under conditions of extreme pressure variation. Valve is normally supplied with ⅛" I.P.T. ports (others may be furnished).—*Modern Products, Ltd., 952 So. Grand Ave., Los Angeles 15, Calif.*



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Long after the ordinary pivot has worn out you'll find PERMO-PIVOTS in the prime of life—faithfully keeping precision instruments precise! It's all due to the special PERMOMETAL tip—the ideal osmium alloy. . . . Made to your specifications.
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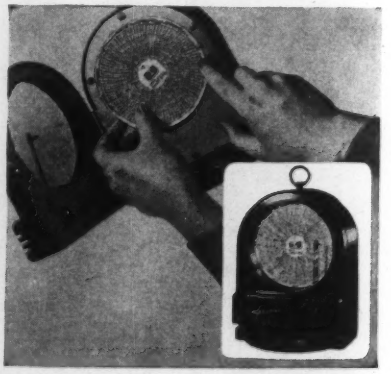
Temperature and Operation Recorders

New "Tempscribe Recorders" for room and atmosphere temperature, and electrical operations, feature easy chart replacement: pen and bimetallic element of temperature recorder, and actuating mechanism of electrical operation recorder, are in door. As shown in illustration, when door is opened pen swings out of the way. Complete interchangeability is another feature: recorder can be converted to any temperature range,

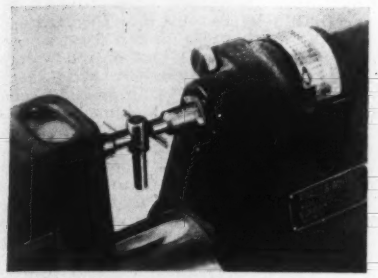


or used as an operation recorder, by changing door of instrument. Door removal simply requires lifting out locking pin from piano-type hinge. Clock movement is in the body of instrument, which fits into a space 4½" × 5½" × 7½". A recess in back of recorder holds extra charts and ink bottle with glass dropper. New recorders are designed so that they can be hung flush, suspended by the ring hook, or simply set in desired place. Bimetallic temperature element of temperature recorders is located in front of door to maximize sensitivity;

operation recorder can be hooked into power line or connected in parallel with load. Temperature recorder 24-hour ranges: −10 to +50°F.; 30 to 60°F.; 40 to 100°F.; 70 to 130°F. and 60 to 90°F.; 8-hour range: 60 to 90°F. Operation recorders: "Type D" with 24-hour movement, "Type C" with 8-hour movement.—*Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Pa.*

Gaging-wire Sets

New complete line of thread and gear measuring wires made of Carboloy cemented carbide are said to be ground and lapped to standard tolerances closer than National



Bureau of Standards specifications, are said to retain accuracy at least fifty times longer than can be expected of steel wires, with no possibility of "flats." New wires are supplied in sets of three in glass bottles labeled to show size of wires and wire-constant corresponding to threads per inch. Wires for N. S. 4 to 36 pitch are available from stock. Wires for other pitches, Whitworth, British Association, Metric, Acme, worm threads and gear wires are supplied on special order.—*Lincoln Park Industries, 1719 Ferris Avenue, Lincoln Park 25, Mich.*

Power Unit for Automatic-control Systems

New "Beck Mechanism" for operating valves, rheostats, autotransformers, etc., makes close control possible under rapidly-changing loads, is said to hold temperature or other conditions to an exact control point free from the drooping characteristic and to permit operation at maximum sensitivity. "Triple-function" control system is based on three control actions: C-1 is proportional to and opposes any change of the

controlled condition within the throttling range. If this were the only control action, a return of the condition to the control point would place regulating device in the position from which it started and, on a sustained load change, continuous hunting would result; or, if throttling range were corrected to avoid hunting, process would settle down at some value off the control point. C-2 and C-3 are the automatic reset or droop corrections which eliminate this effect. C-2, major part of correction, is proportional to C-1 action and is introduced to the system as fast as it can be absorbed but not faster. C-3 action consists of an impulse periodically introduced when sys-

AUDIO SIGNAL SYNCHRONIZER—MODEL J for Synchronization of Audio Frequencies

This instrument is essentially a dual input, sensitive vacuum tube voltmeter. In production and laboratory test procedures, typical applications are: synchronizing audio oscillators with radio WWV, calibrating modulation frequencies of transmitters, adjusting filter networks and tuned circuits —or any application where a beat must be observed down to a few cycles per second.

The usual procedure with cathode ray techniques requires considerable time for interpretation of frequency differences. The Model J will synchronize and give direct indication of frequency differences as low as one beat in 24 hours. The gain of each input, for full scale deflection on the meter, exceeds 60 D. B.

Input impedence is 500,000 ohms over the audio spectrum and is constant at any setting of the input attenuators. The inputs are isolated from each other and have no electrical effect on the signal mix. A jack is provided so that the output synchronized signal may be used to drive an oscilloscope.

Dimensions—19" L x 8-¾" H x 9-½" D
Furnished in oak cabinet if relay rack mounting is not desired.

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tem is off control point, to move regulating device in proper direction to restore system to control point. This is a timed action and is proportional to deviation. C-3 prevents system from staying off control point owing to some unusual combination of demand change and control action. It is said that the solution of many industrial control problems can be simplified and improved by taking advantage of "the many unique features" of this control mechanism. Each Beck Mechanism is driven by a slow-speed high torque non-coasting Beck control motor. A non-mechanical magnetic brake assures accurate reproduction of minimum turndown and non-hunting control action without sacrificing sensitivity of the control system. Heavy motor shaft turns in grease-sealed ball bearings. Armature can be stalled without damage to mechanism and stalled motor will not overheat.—*Harold Beck Co., 3644 North Second Street, Philadelphia 40, Pa.*

Audiofrequency Oscillator

New -hp- "Model 201B Audio Frequency Oscillator" will meet requirements for speed, ease of operation accuracy and purity of wave-form, in FM and other fields where high fidelity is important. It has an accurate convenient method of frequency control: the 6" dial, with smooth ball-bearing action, may be tuned by a directly-controlled knob or, for greater accuracy, may be set by vernier illuminated main dial, designed so that parallax is eliminated. is calibrated over 300° with approx. 95 calibration points and has an effective scale length of about 47". Frequency range is 20 cps. to 20 kc. Amplifier delivers up to 3 watts of power into a 600-ohm resistance load, with distortion held to 1%. Thus there is sufficient power available for driving almost any kind of laboratory or production equipment. Harmonic distortion may be kept to less than 0.5% if output of amplifier is limited

to 1 watt. Provision is made for standardizing each frequency range against a reliable standard. A volume control ahead of amplifier controls voltage at which amplifier operates. An output attenuator attenuates signal delivered by amplifier. Attenuation is approximately linear from zero to 40 db. Both hum level and output voltage are thus attenuated together. As a result, hum level may be kept 60 db or more below signal level. Impedance looking back into output circuit is about 50 ohms; thus voltage regulation for varying loads is extremely good. Improved chassis layout and placement of component parts minimizes thermal drift. Voltage on oscillator is maintained constant with an electronic voltage regulator. Entire instrument is characterized by greater rigidity; tuning assembly is mounted on cast aluminum frame; chassis itself is made of aluminum; oscillator is light in weight and easy to handle.—*Hewlett-Packard, Inc., Palo Alto, Calif.*

Simplified Master Taper Attachment Fits All Types of Lathes Instantly!

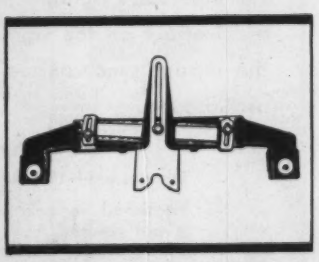
Now! A "universal" taper attachment that fits all lathes, old or new, big or small—that can be attached or removed in *minutes!* This taper attachment is not bulky or cumbersome. It bolts easily to the bed, in the back of any lathe.

The Master performs accurate taper turning, boring and threading with the ease of any straight line tool operation. It precisely duplicates any tapered part. Is usable in any position. Does not interfere with straight turning. The bar is precisely machined and fitted. There is no vibration. Taper graduations are in inches at one end; degrees at the other. The Master is available now, in two sizes; two feet and four feet in length.

Available today also, is delicious Wrigley's Spearmint Gum. This is one treat you can enjoy even when your hands are busy. And the pleasant chewing helps to keep you alert and wide-awake, even through a monotonous job.

Chewing Wrigley's Spearmint satisfies a fellow. In addition, it helps keep your mouth moist and fresh—so you feel better. And feeling better, you naturally work better. By making gum available to all, scores of plants and factories report increased morale and efficiency that really pays off.

You can get complete information from the Keene Electrical Machinery Co., 549 W. Washington Blvd., Chicago 6, Ill.



Model 710 Master Taper Attachment

AA-63

Wire-wound Precision Resistors

New precision resistors, made in five sizes, have a standard tolerance of 1% but tolerances of 0.5%, 0.25% and 0.1% can be furnished. Steatite winding forms insure insulating qualities, mechanical strength and permanence. Terminal lugs of hot-tin-dipped brass are securely fastened to winding form. Resistance wire is of Ni-Cr or Cu-Ni alloy. Wire is non-inductively section-wound by

machines maintaining correct wire tension; ends of winding are soldered to special tab on terminals. New resistors are protected against humidity and corrosion by double impregnation of insulating varnish; an external coating insures against entry of salt spray or dust. "Type AFB" is 9/16" diameter by 15/32" long; "Type AGC" 5/8" × 5/8"; "Type AGF" (illustrated) 5/8" × 1"; "Type AJS" 3/4" × 1 9/32"; "Type ALP" 7/8" × 2 1/16". Maximum resistance with 0.0014" diameter Ni-Cr wire: "Type AFB" 0.225 meg.; "Type AGC" 0.450 meg.; "Type AGF" 0.800 meg.; "Type AJS" 1.50 meg.; "Type ALP" 2.75 meg.—*Resistance Products Co., 140 South Second Street, Harrisburg, Penna.*

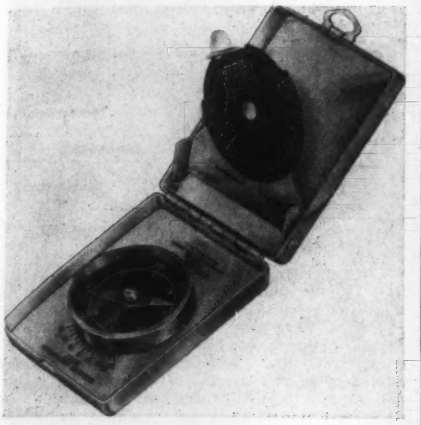
Hermetically-sealed Selenium Rectifier

New selenium rectifier can be submerged in boiling water or packed in ice and still turn a.c. into d.c. at an efficiency equal to that obtained under normal operating conditions—a performance said to have never before been achieved with a plate type rectifier. New unit consists of a heavily-tin-plated hermetically-sealed container inside which is placed selenium suspended in oil. Designed to keep pace with the exigencies of war, it has unequaled invulnerability to high and low temperatures insuring top performance in any climate from the North Pole to

the Equator. It will operate with only a slight drop in current output at a temperature higher than the boiling point of water and will last much in excess of 1,000 hours. Salt spray which will destroy in a few hours an unprotected rectifier on the deck of a ship does not interfere with performance of new unit, which is also impervious in tropical areas to attacks of insects, fungi and humidity which quickly ruin the ordinary open type rectifier — *Westinghouse Electric Corp., East Pittsburgh, Penna.*

Combination Sun Watch and Compass

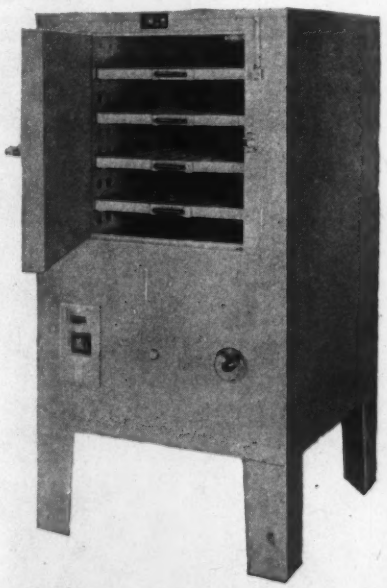
New "Boyd Sun-Time," described as modern postwar version of an ancient horological device, tells time with accuracy "as



sure as the sun shines," is intended for use when fishing, hunting, flying, sailing or motoring. No winding or setting is necessary. It is waterproof, compact and durable. Solid brass case is polished and lacquered. Compass has an unbreakable crystal and a luminous jewelled needle.—*RFL Sales Co., 185 Madison Avenue, New York City.*

Aging Ovens

New automatically controlled aging ovens were specially designed for aging of products requiring a series of temperature changes from room to 180°C. with each change to



be held automatically for a predetermined period. They are thermostatically controlled throughout entire range with a sensitivity of ±1°C. and are mechanically convected with a sealed-in blower unit which develops 550

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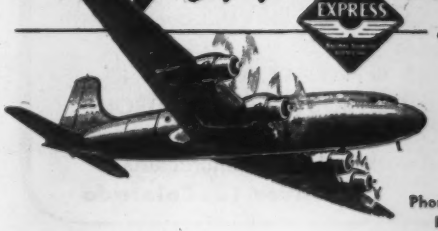

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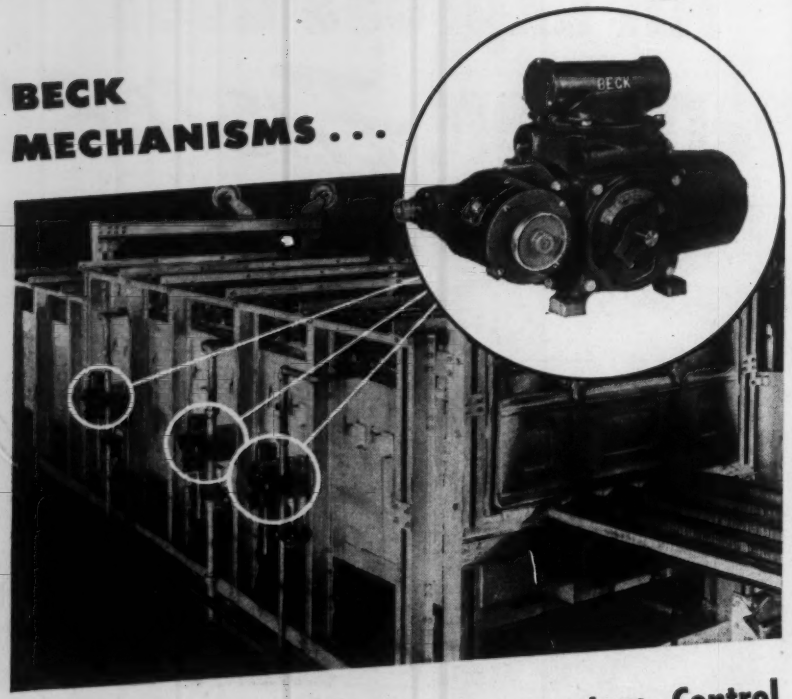

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The gas flow to each zone of this tempering furnace is precisely controlled by a Beck Mechanism. Thus, the full sensitivity of the temperature detecting instrument is utilized and any motion, large or small, of the instrument slidewire is exactly compensated for by the proper valve action. The Beck non-coasting motor eliminates any movement which might follow the opening of a circuit and the mechanism is so designed that any wear which may take place will not affect accuracy.

The Beck Triple-Function Control holds temperature steadily at the control point—with no drooping characteristic—and acts rapidly to return temperature to the control point when load conditions change. This is correct theory, correctly applied. Once installed you can be sure of dependable service.

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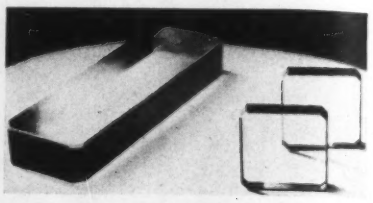
cfm., permitting rapid heat transfer, increasing heating efficiency to well above that which would be produced by gravity convection, and permitting increased loading capacity. A "Timeostat" automatically controls predetermined temperature-time cycle for periods up to 24 hours, and will also control a time lock on door to prevent interference during aging process. It can be manually reset at any point in operation. Ovens are available with interior compartments ranging in size from 2.25 to 27 ft.³ —*The Electric Hotpack Co., Inc., 1225-29 Cottman Street, Fox Chase 11, Pa.*

Square and Rectangular Optical Flats

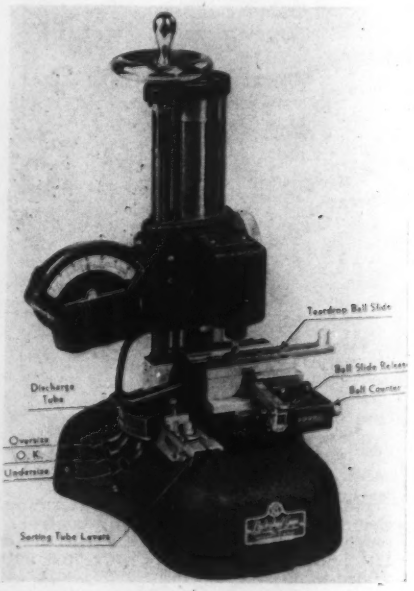
New "Optron" square and rectangular optical flats are claimed to be more economical and easier to handle than those of conventional round shape. For example, a 10" ×



2⅜" flat can be used in place of a round flat 10" in diameter, weighs one-fourth as much, can be safely handled with one hand. Fear of breakage or damage is reduced. Straight edges of new flats provide reference lines for comparison of straightness of interference bands, often making it unnecessary to use rules or straightedges; and removing another possible cause of scratching the fine surfaces. New flats are guaranteed to be flat within 1/10 wave (two microinches) and furnished square up to 6" × 6" or in bars up to 10" × 2⅜". *Optron Laboratory, 2662-A Salem Avenue, Box 25, Dayton 6, Ohio.*

External Comparator with Ball-sorting Attachment

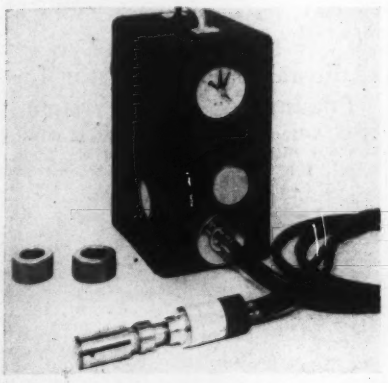
New "Model BE-748 Electrolimit Ball Sorting Gage" provides a fast and accurate method of quality inspection, by mechanical operation, of small lots of precision balls. With addition of "Cup Type Hopper and Tube," readily attached to instrument, operator's time can be greatly speeded. Tear drop in ball slide allows positive positioning of the ball between T-C button on anvil and diamond gaging point, when ball slide



is in the gaging position. Deflection of ball slide release lever allows slide to be moved from gaging position to unloading position while tripping ball counter. Ball slide can be conveniently operated to and from loading position by right index finger, right thumb depressing ball slide release lever. Sorting tube levers are conveniently positioned for left hand and allow simultaneous operation with functions of right hand, thus providing for rapid operation. Indicator can be graduated to permit ball inspection to "tenths," "half tenths" or "hundredths."—*Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford 1, Conn.*

Comparator with Booster Relay

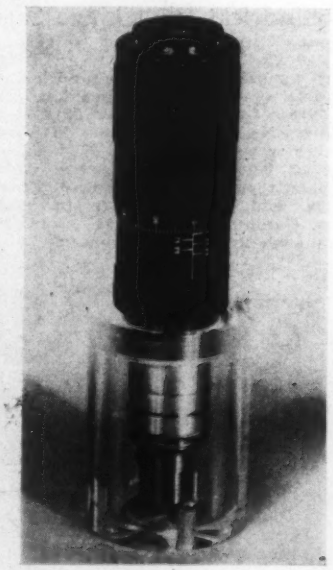
New "Model R2 Air-O-Limit Comparator with Booster Relay" enables hand gaging to be done at a distance from maker's



"Air-O-Limit" comparator: the booster relay permits the use of any length hose between gage cabinet and gage plug without any loss of speed or accuracy in the gaging operation.—*Pratt & Whitney, Div. Niles-Bement-Pond Co., West Hartford, Conn.*

Optical Micrometer for Transparent Materials

New "Aireon Optical Micrometer" was invented and perfected by an internationally-known scientist to satisfy special gaging requirements of plastics and glass: The ordinary mechanical micrometer measures thickness of small flat pieces of Lucite, Plexiglas or plate glass without trouble but when sheets are large it becomes imperative to determine thickness of central portions in positions inaccessible to ordinary micrometer. Also, measurement of



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Two models for all conditions. Self-contained power source. NO CRANKING. Resistance values are read directly at potentiometer pointer knob.

MODEL 251 (illustrated). Triple range: 0-12.5, 0-125, 0-1250 ohms. Recommended for average ground conditions.

MODEL 255, four ranges: 0-3, 0-30, 0-300, 0-3000 ohms. For extremes of dryness or moisture.

Both models complete, ready for operation. Accessory kit No. 7104 available—eliminates confusion of selecting make-shift materials. Wire or write for bulletin with diagramatic drawings and full details. PROMPT DELIVERIES ON ALL ORDERS.

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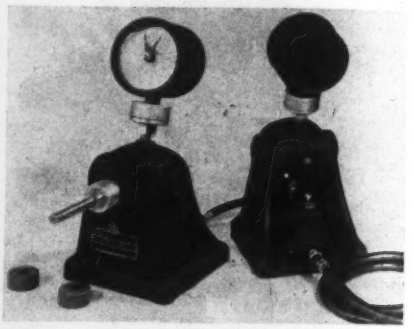
curved plastic sheet is exceedingly difficult by ordinary means since ball head of mechanical micrometer tends to sink and there is always risk of optical surface being damaged. Still another problem arises when acrylic windows in airplanes must be measured for thickness. For these and similar cases, new optical micrometer utilizes principle of apparent depth. Essentially, instrument consists of a microscope which can be screwed up and down in an outer tube. Lower end of this tube is a plastic nosepiece held against sheet to be measured. Transparent sheet is marked with a crayon on the side away from instrument and the measurement consists in sharply focussing the mark in the microscope. Readings on barrel and thimble, just as in an ordinary micrometer, give directly thickness of sheet, to 0.001". Two scales: 0 to 0.4" and 0.4" to 1.5". It takes about the same time to obtain reading with new instrument as with purely mechanical microscope.—*Aireon Mfg. Corp., 166 W. Olive Avenue, Burbank, California.*

Adjustable Compensator for Pneumatic Gaging System

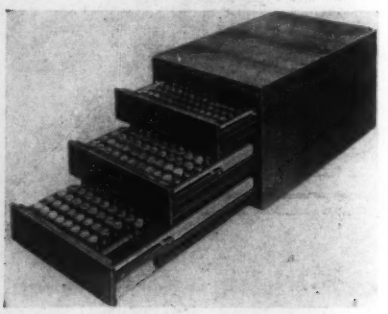
New Adjustable Compensator is designed to obtain higher magnification for maker's "Model B2 Air-O-Limit Comparator." It



can be readily attached to the Comparator and allows full-scale graduations of 0.0004", 0.0006", 0.0008", and 0.001", to replace full scales of 0.002", 0.003" and 0.004" that are normally used. In addition to higher magnification, it offers further advantages of greater diametral clearance, better side compensation, longer wear life and greater speed at the higher magnification. A special series of gaging plugs is required, as those regularly used with Comparator are not satisfactory for new Adjustab'e Compensator.—*Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford 1, Conn.*

Cylindrical Plug Gage Sets In Cabinets

New complete standard cylindrical plug gage sets are housed in durable cabinets, with features of convenience. Three-drawer "Cabinet No. 500" contains 471 gaging members, sizes 0.030" to 0.500" in increments of 0.001" (each member with its own plastic collet) seven new lightweight handles, and four drifts to fit all size ranges. Gaging members are progressively stored, each in its own receptacle. Size of



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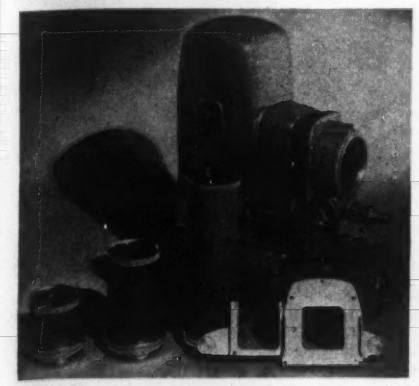
gage is stamped on collets for instant pick-up. "Cabinet No. 600" contains 501 gaging members in four drawers. Sizes 0.500" to 1.000" in increments of 0.001". Plastic collets are included for each pin; also four of the light-weight handles, and four drifts to fit all size ranges. New cabinets are designed for toolroom service. Sliding drawers are double suspension ball-bearing equipped, tumbler lock. Sizes: No. 500, 16" × 25¼ × 12¾"; No. 600, 21-9/16" × 27⅛" × 20". Gaging members are available in XX, X, Y, Z, and ZZ tolerances. New plastic collets are said to be greatly superior to metal: light, tough, corrosion-proof and insulating. Gaging member with collet is removed only by drift, no scratching.—*United Precision Products Co., 3524 W. Belmont Avenue, Chicago 18, Illinois.*

Slide Projector

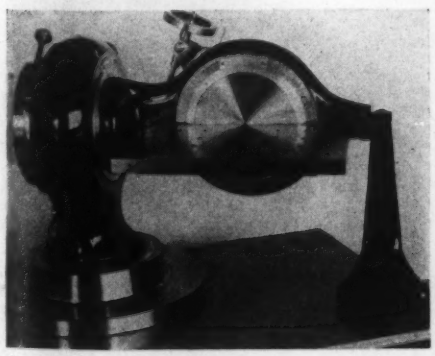
New "Slide Master" will portray on the screen all the fine details of photography actually contained in the slide. Among new features: 500-, 750-, and 1000-watt lamps



are interchangeable without any modifications; cooling by quiet, Neoprene-mounted motor and fan, motor speed is thermostatically controlled and increases when additional cool air is needed for higher wattage lamps; highly efficient optical system, condenser assembly includes double heat-absorbing filter having high light transmission power; choice of 3½" or 5" F 4.5, or 7½" F 4.8 projection lenses, all anastigmatic, all interchangeable, which may be locked in focus.—*Bell & Howell Co., 7100 McCormick Road, Chicago 45, Illinois.*

Angle Computer

New "Model G" Angle Computer is for layout and inspection of tools, dies, jigs, fixtures, castings, patterns, forgings and any layout work or inspection involving angles or compound angles. It is claimed that a saving of 50% to 90% in time is effected by its use. In most instances only one set-up of the work is required since surface plate on "Model G" may be rotated 360° in each of three directions of rotation: horizontally, vertically and radially. To use "Model G," it is only necessary to clamp work to adjustable surface plate. By means of the actuating mechanism exact position



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These transformers are designed for use with vane type ammeters which are used on frequencies from 25 to 133 cycles.

Maximum accuracy is obtained at 70% of full scale value and is dependent upon the number of primary turns used. Accuracy is directly proportional to be the number of primary turns.

These transformers are designed for a capacity of two volt-amperes and the secondary windings are of such size as to allow in excess of 800 CM/ampere at maximum rating.

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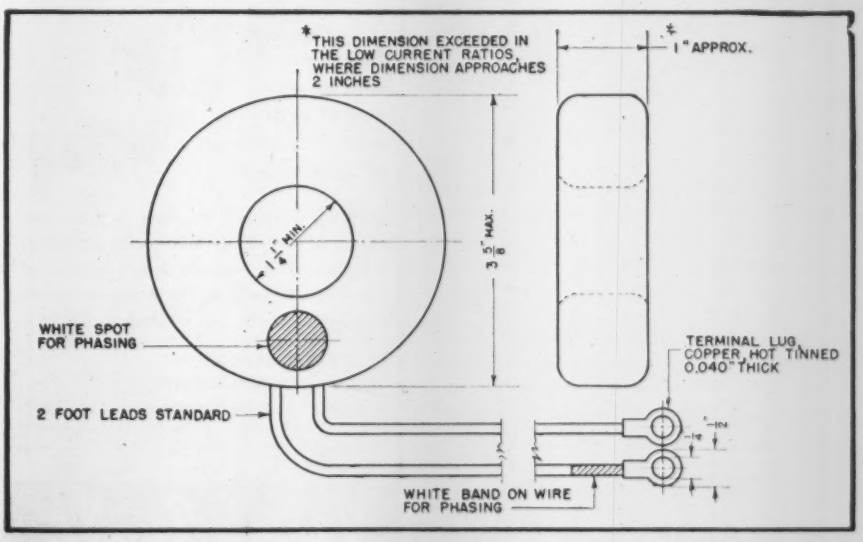
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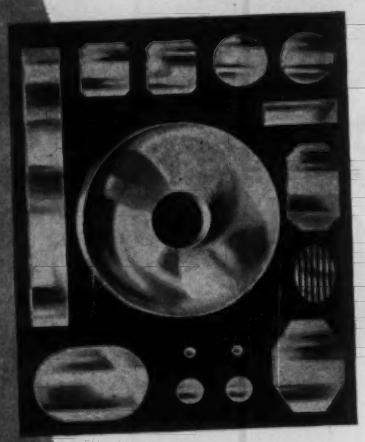

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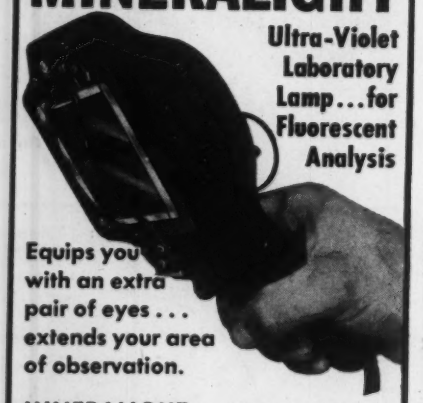

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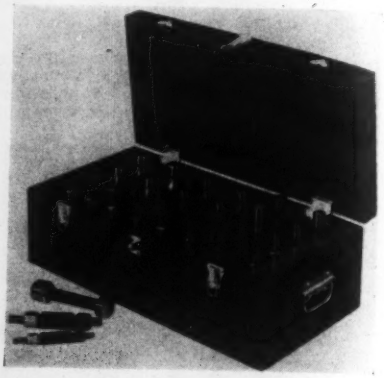
to 0.0001" or to one minute of arc can be quickly and easily located. Thus a part having a number of angles and related angles may be quickly and accurately surveyed. Surface plate is 9" × 16". Diameters of protractors are: horizontal 9¼", vertical 9¼", radial 10". Base diameter is 18", height 21", length 32". Weight about 530 lbs.—*The Angle Computer Co., 1709 Standard Ave., Glendale, Calif.*

Reversible Gage and Wire Set Cabinets

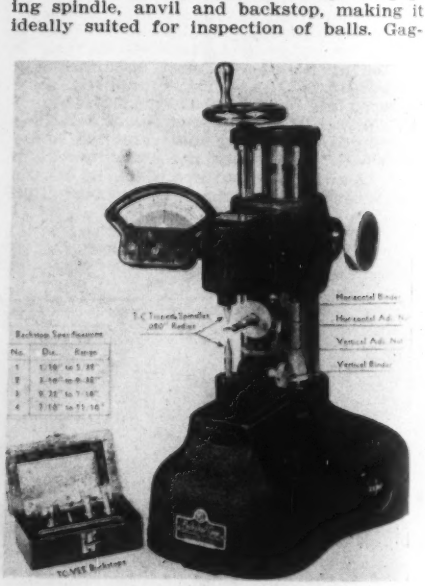
New complete line of standard reversible gage sets in cabinets is announced. Thread gages are available in Size Con-



trol (patent pending) reversible type said to have been found to be most economical design for a plug gage as well. They are made up in partial or complete thread series in storage and carrying cabinets with each plug hole properly identified. Plain plug gages, also of reversible design, are available in old or new A.S.M.E. recommended drill sizes, also in fractional sizes in any combination of increments of 0.001" or by any other size arrangement. Standard thread or gear wire sets in any recommended series made to National Bureau of Standards specifications also are available from stock. These sets are said to be of special value in experimental laboratories, or shops requiring gaging of many different short run operations. —*Size Control Div., American Machine & Gage Co., 4636 W. Fulton St., Chicago 44, Ill.*

External Comparator with Ball-gaging Anvil and Backstop

New "Model CE-699 Electrolimit External Comparator" is equipped with a special gaging spindle, anvil and backstop, making it ideally suited for inspection of balls. Gag-



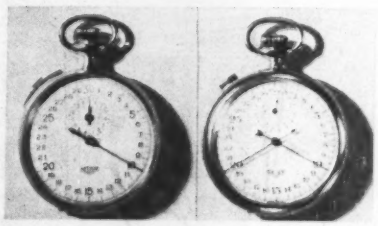
ing spindle and anvil are identical pieces having a T-C gaging tip with 0.020" radius. Backstop is a T-C vee located in anvil fixture with provision for both vertical and horizontal adjustment. Indicator can be graduated in "tenths," "half-tenths" or "hundredths."—*Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford 1, Conn.*

Stopcock Lubricant

New "TruTest Stopcock Lubricant" is said to be an all-purpose, stainless, reasonably priced, thoroughly resistant lubricant that prevents sticking of stopcocks of all types on laboratory equipment. It is nonvolatile, with low vapor pressure, to ordinary acids, methanol, acetone, alcohols, benzol and alkalis, and hot lye. It is nonsoluble in water and is compatible with all aqueous reagent solutions. Its consistency, about the same as vaseline, is said to remain unchanged between —40°C. and approx. 93°C. It will not freeze, stiffen or lose its lubricating quality at any elevated temperature within its operating range. Melting point is approx. 120°C. (248°F.). In addition to lubricating metal, glass and ceramic stopcocks, it can be used as a facilitating lubricant in fitting and removing rubber connections on apparatus, also for sealing purposes.—*TruTest Laboratories, Inc., 261-263 S. 3rd St., Philadelphia 6, Pa.*

Time-study and Test-timing Watches

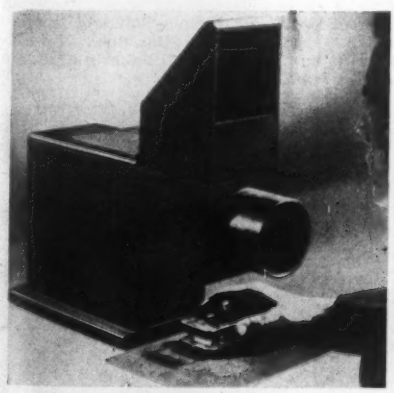
New on American market, "Heuer Timers" are offered to manufacturers interested in checking production output, setting up production schedules, checking speed of men

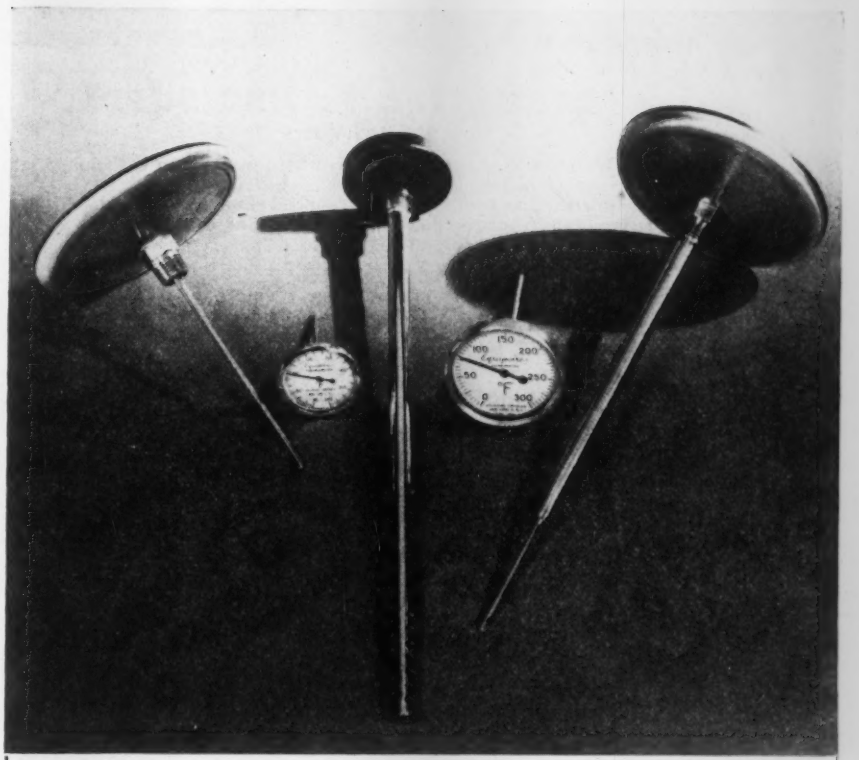


and equipment, meter testing, testing viscosity, or in other operations in which split-second timing is required. Heuer timers come in a wide variety of models, calibrated in 1/5 seconds, 1/10 seconds or 1/100 of a minute, with or without time-out features for timing interrupted motions or performances, and with or without split action for timing simultaneous operations. They are made by a firm that has specialized in timers and chronographs exclusively since 1864. They are unaffected by magnetic fields.—*Louis Aisenstein & Bros., 630 Fifth Avenue, New York 20, N. Y.*

Interference-band Viewer

New "Interference Viewer" makes possible uniformly accurate measurements of gage blocks, anvils, sealing surfaces, etc. It is of entirely new design, in that the in-





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Employs the special tooling and experience gained in making thousands of the same type instruments for the Army Air Forces. Meets industry's demand for greater sensitivity and accuracy. Many standard ranges are available between the limits of minus 90°F. and 1000°F.

- Easy to Read Dial
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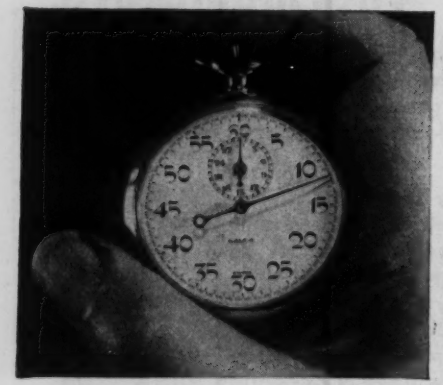

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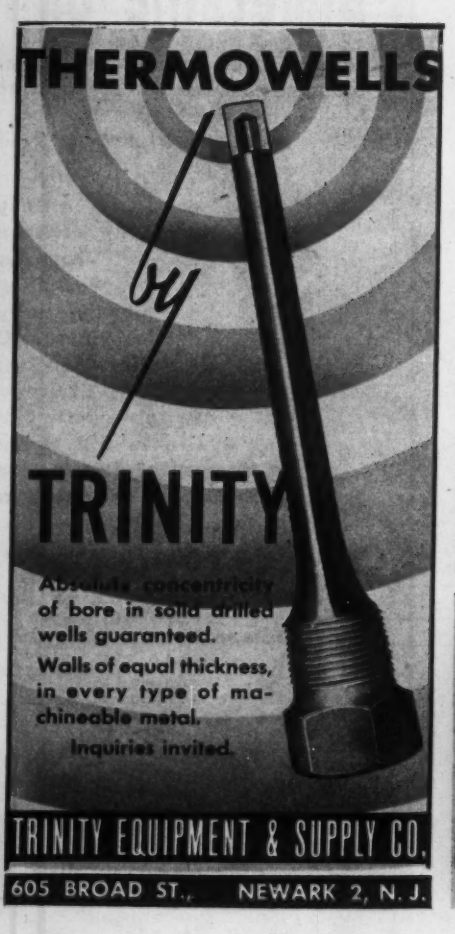
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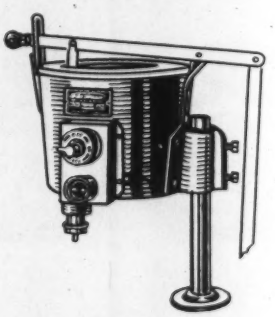
terference patterns are both illuminated and viewed on a line perpendicular to plane of pattern. Distortion of pattern, prevalent in conventional interferometers, is eliminated. Each pattern appears the same to different observers, simplifying inspection of one pattern by several observers and removing chief difficulty of instruction in optical measurement techniques. Monochromatic light source is completely concealed, relieving eye strain, eliminating confusing reflections and ghost images which make uniform measurements difficult. Type of light source was selected to give interference patterns maximum brightness and sharpness. Viewer incorporates a feature enabling user to superimpose the image of any convenient scale on the interference pattern itself, permitting convenient comparisons of straightness or direct measurements between interference bands, without using a ruler or straightedge. Viewer permits user to sit while viewing patterns—an advantage when large numbers of gaging operations are to be performed. It is also claimed that this viewer is the only commercially available device which permits the use of Haidinger bands in tests for parallelism, without accessories of any kind. Deviations in parallelism from ½ to 15 seconds of arc can be readily observed.—*Optron Laboratory, 2662-A Salem Ave., Box 25, Dayton 6, Ohio.*

Thermostat-controlled Wax Dispensers

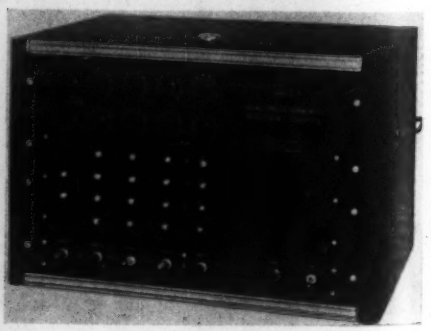
New wax heaters and dispensers embody automatic temperature control system, are available in eight capacities from 2 quarts



to 25 gallons, with orifices from ⅛" to ⅜" (larger orifices special).—*Sta-Warm Electric Co., 456 N. Chesnut, Ravenna, Ohio.*

Dual Predetermined Electronic Counter

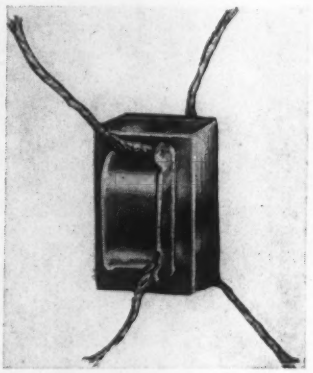
New "Dual Predetermined Electronic Counter" was developed for use in a number of different industries. In slide fastener production, length and spacing of fasteners can be varied quickly and conveniently and greater accuracy of fastener length is assured. In counting and packaging of small items, economy is realized by eliminating usual ratio weighing process or hand-operated scoops. In rolling mills, predetermined numbers of rapidly-moving sheet stock can be counted, after which a solenoid is energized to stop or divert the flow. New instrument employs four of maker's standard



4-tube counter-decade circuits, arranged to give two independent predetermining channels in which any number from 0 to 10,000 may be initially set up by manipulating rotary switches mounted on front panel. During operation of equipment, each channel is alternately preset to desired predetermined number. This function is accomplished automatically by self-contained circuits, and occurs in less than one millisecond. Input is arranged for operation with either make-contacts or with sharp negative pulses, as specified. Input frequencies may be in excess of 1000 cps. Output consists of an ultra-high-speed relay with single-pole double-throw contacts. This relay is energized at the end of one predetermined count cycle and remains energized throughout the other predetermined count cycle. Instrument is designed to meet rigid requirements of industry. Operation is from 110-volt 60-cycle supply.—*Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.*

Miniature Transformers

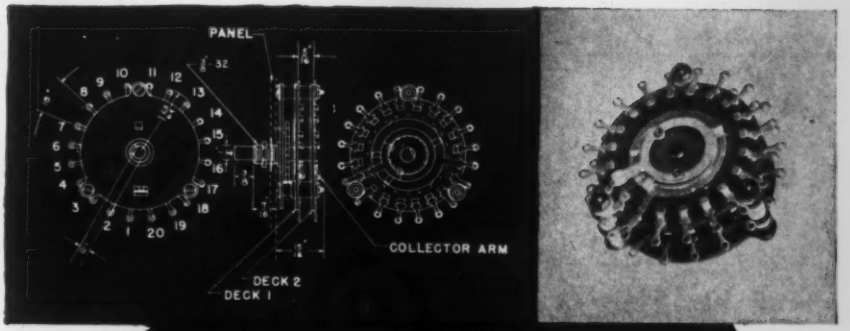
New "Sub-Ouncer" transformers thus far only used in military equipment where smallest possible weight and volume were



a prime consideration, are being made available for use in hearing aids, vest pocket radios, etc. They measure 9/16" × 5/8" × 7/8", weigh 1/3 ounce, but are said to have superior performance and dependability characteristics. Coil is uniform layer-wound of Formex wire on a molded nylon bobbin. Insulation is of cellulose acetate. Leads are mechanically anchored externally. Core material is Hipermalloy. Entire unit is triple (waterproof) sealed. Five standard models are available for immediate delivery from stock, frequency response ±3 db from 200 to 5000 cps.—*United Transformer Corp., 150 Varick St., New York 13, N. Y.*

Diagnostic X-ray Apparatus

New two-tube diagnostic x-ray apparatus, said to embody all standard design principles which U. S. medicos have evolved from years of study and usage, introduces new and unique features among which are: (1) Duo-rail tubestand with large vertical column eliminating vibration and insuring pin-point sharpness and clarity on x-ray film; (2) Large roller bearings in base casting and on cable supports making transverse movements of the tubestand almost effortless. (3) Tube completely rotatable around vertical column, permitting work over a wheel stretcher on opposite side of stand and affording utmost radiographic flexibility. (4) All tubestand motions may be locked by means of controls on front working side of table. (5) New gearing design moves table through 120° with ease, yet maintains any position without brakes or locks merely by leaving handcrank in selected position. Handwheel is flush with leg casting and handle folds into wheel to allow complete operational freedom. (6) Table is available in a hand-crank model providing shockproof fluoroscopy and spot-film recording beside table-top and Bucky radiography. (7) Table is at a convenient



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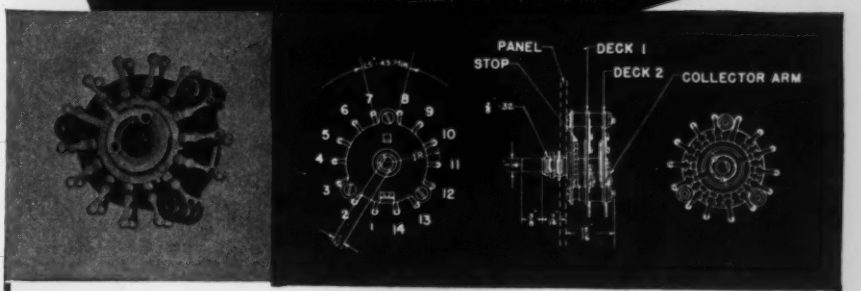
ON THE TROUBLESHOOTER'S CHECK LIST
AND PROUD OF IT!



J-B-T Instrument Type Rotary Selector Switches are available in 20 position SS-20 and 14 position. SS-14 models, one to six decks, non-shorting standard, and shorting on special order.

. . . for these are the instrument and tester makers own switches, designed and developed to meet the need for trouble-free, dependable performance in hard service.

They are extensively used in high quality test equipment, portable instruments, in inspection set-ups, and experimental circuits.

Now, because of quantity production, they are in a price range which makes it sensible to consider them for many other electronic applications. And they are available for immediate delivery. Your jobber probably has them in stock by now.

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Dial indicates strain directly in micro inches per inch.

Completely self contained in one unit.

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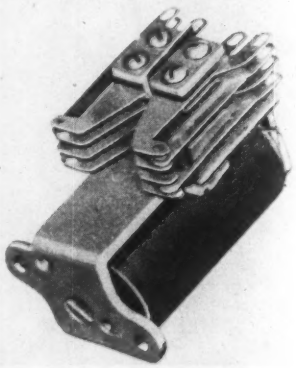
working level when horizontal, yet permits easy transfer of a patient from a stretcher. (8) Bucky diaphragm is perfectly counterbalanced to facilitate use in vertical or other intermediate positions. Bucky can be controlled through the timer or independently. (9) Exclusive fluoroscopic screen three-position locking device allows for locking, unlocking and compression by a simple sweep of the lever. (10) Combination shoulder rest, foot rest and seat locks firmly into position at various points along table. (11) Fluoroscopic screen is interchangeable with spot film device. New diagnostic x-ray apparatus measures approx. 28½" table width, 6'6" table length, 34½" table height (horizontal), 7'8" tube stand height, is finished in gray and black with chrome metal trim. — *North American Philips Co., 100 East 42nd St., New York 17, N. Y.*

Multi-pole Relay

New "Series No. 98330" midget a-c. multi-pole relay with shunt coil is designed for electronic and communication applications. Standard 60-cycle a-c. voltages range from



1½ to 220. Contacts are available in one to four poles, normally-open, normally-closed or double-break. Double-throw contacts can be "break before make" or "make before break." Maximum contact rating (non-inductive), 3 amperes, 24 volts a.c., 1 ampere, 110 volts a.c. Coil rating is 11 volt-amperes inrush; five volt-amperes sealed. This relay is also available in single-pole normally-open double-break contact. 10-ampere rating, at 115 volts a.c. Approx. over-all dimensions: 1-15/16" long, 1-9/16" high (four-pole, double-throw); 1-9/16" wide. Heel piece of magnet frame has two tapped holes for rear mounting and two pierced holes for front mounting. Solder type terminals.—*R. B. M. Division, Essex Wire Corporation, Logansport, Ind.*

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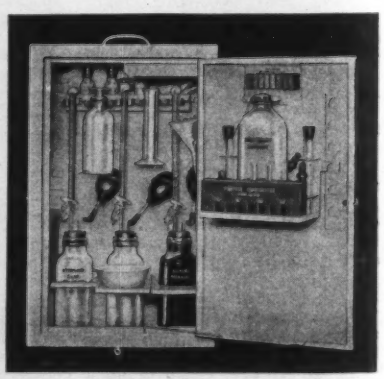
New "Testmaster Junior" is a simplification of "Testmaster," retaining parent model's major functions. For any plant where hardness, alkalinity to P & M and



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Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

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INTERVAL TIMERS, or PROCESS TIMERS, are furnished in two types. One is reset by hand (manual); other resets itself, automatically. Both types can be provided for practically any cycle of time, fully adjustable from zero to maximum period. SYNCHRONOUS, SELF-STARTING MOTORS.

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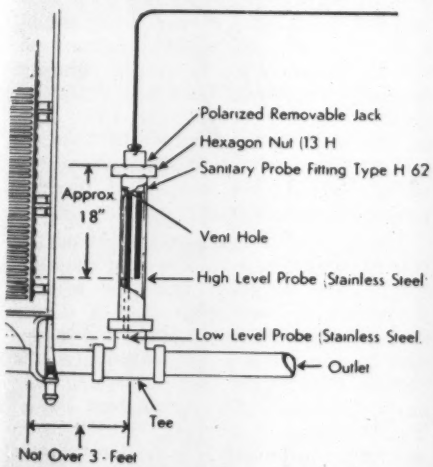
chloride determinations are adequate for dependable water control, "Testmaster Junior" is said to provide complete apparatus and the reagents for making these tests. Moreover, these tests can be made by any intelligent layman after a brief period of instruction. Where it is desired to incorporate wide range pH and phosphate determinations, "Testmaster Junior," same cabinet, without modifications, will accommodate makers' Phosphate Tray and pH Test Unit. Thus, "Testmaster Junior" is potentially available for all normal water control tests except dissolved oxygen, is recommended for laundries, cleaning and dyeing establishments, beverage plants, breweries, wineries, distilleries, textile mills and many chemical plants where use of regular laboratory for routine and complete water analysis is not feasible. *TruTest Laboratories, Inc., 261 S. 3rd St., Philadelphia 6, Penna.*

Beam Tetrode

New "TB-35" uhf. beam tetrode operates with full power input up to 250 Mc. and at half-power input to 400 Mc., is said to fill a definite need for a tube with a power output of over 125 watts in these ultra-high-frequency regions. Tube has a four-pin ceramic base and plate connection is brought out at top of envelope. Overall size is 4-⅞" and max. diam. is 1-⅝". Electrical characteristics: Filament, thoriated tungsten, 6.3 volts at 3 amps; Mu—65 approx.; Mutual conductance at Ib 0.08—2750 micromhos; Interelectrode capacitances—Input to plate 0.2 mmf, Input 6.5 mmf, Output 1.8 mmf. Typical operating conditions, Class C, plate modulated with a maximum modulation factor of 1.0: d-c. plate volts, 1000; d-c. grid No. 1 volts, 200; d-c. grid No. 2 volts, 300; d-c. plate current, 85 ma; d-c. grid current, 10 ma; peak rf. grid input voltage, 250; driving power, 2 watts; plate power output, 60 watts.—*Taylor Tubes, Inc., 2312 Wabansia Avenue, Chicago, Illinois.*

Sanitary Level Control

New "Series P17 Sanitary Level Control" makes available to dairy and food-processing industries a series of rugged electronic



relays for level control of all liquids. Contact with the sanitary liquid is made only by a stainless steel probe rod—no floats or other moving parts being required in the tank. Accuracy is said to be maintained regardless of temperature or pressure. "Series P17" is the only floatless level control containing no vacuum tubes and operating with low voltage in the probe circuit. It meets requirements of all sanitary and health boards. Specifications: Supply: 115- or 230-volts 60-cycles a.c. Power consumption, ½ watt. Output: Single-pole double-throw relay. Contacts: 300 watts at 115- or 230-volt a.c. Probe circuit: Will carry a resistance as high as 3,500 ohms.—*Photoswitch, Inc., 21 Chestnut St., Cambridge, Mass.*

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Speeds tests of insulating oils

ACCURATE—Potentiometer raises test voltage gradually, prevents surges. Voltmeter indicates applied kilovolts accurately.

CONVENIENT—Inclined panel, removable testing receptacle, and light weight (80 lb), make operation easy.

SAFE—All live parts enclosed. Safety switches, automatic circuit breaker, and ground conductor for maximum protection.

This portable G-E oil tester helps you get longer service from liquid-insulated electric apparatus. It gives quick, accurate field checks on the dielectric strength of the liquid. Compact, lightweight construction means easy carrying. Over-all safety devices give protection at all points, reduce accident hazards.

Everything about this portable tester is designed to give top service in generating stations, substations, industrial plants, and wherever frequent testing is required. It will help you get better performance and lower operating costs. Write us for Bulletin GEA-4477. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

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Laboratory Standards

MODEL 62

VACUUM TUBE VOLTMETER

SPECIFICATIONS:

RANGE: Push button selection of five ranges—1, 3, 10, 30 and 100 volts a. c. or d. c.
ACCURACY: 2% of full scale. Useable from 50 cycles to 150 megacycles.
INDICATION: Linear for d. c. and calibrated to indicate r.m.s. values of a sine-wave or 71% of the peak value of a complex wave on a. c.
POWER SUPPLY: 115 volts, 40-60 cycles—no batteries.
DIMENSIONS: 4¾" wide, 6" high, and 8½" deep. **WEIGHT:** Approximately 6 lbs.
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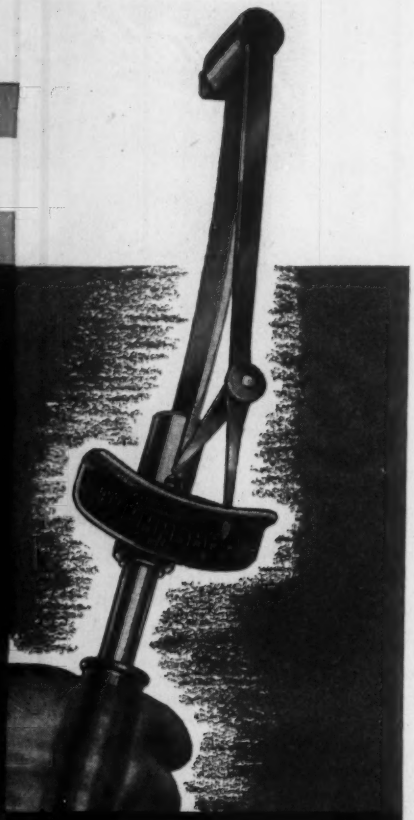

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The Hydrogen Thyratron

Concluded from Page 211

The hydrogen thyratron is controlled by applying a trigger voltage of desired repetition rate to its grid. The pulses are transmitted over a pulse cable which feeds an impedance-matching transformer with a magnetic load. This transformer is of special design to pass the sharp pulses to the load without appreciable distortion. The pulse transformer is usually designed to allow 4 to 5 times step-up in voltage. This feature provides the pulse voltage required by medium- and moderately-high-powered magnetrons. The pulse cable impedance is matched to that of the pulse-forming line and permits placing the magnetron in any position in the system. With proper circuit design, tubes can be operated in series to increase the voltage and in parallel to increase the current.

Type 4C35 tube is capable of pulsing medium-power tubes and has a peak voltage rating of 8 kv. and a peak current of 90 amperes. This corresponds to a peak power of 360 kw., neglecting losses in the various circuit components. Type 5C22 will handle peak voltages of 16 kv. and a peak current of 324 amperes, corresponding to peak power of 2600 kw. at a maximum frequency of 560 pulses per second. The repetition frequency can be increased at lower powers. A typical operation condition might be 100 kw. of peak power at a repetition rate of 1500 pulses per second and a maximum average power of 1000 watts.

Both types of tubes require the same grid drive, which is specified as a voltage pulse having a certain peak amplitude, rate of rise, pulse duration and source impedance. A simple compact trigger circuit can be made with two small receiving tubes. The tube drop of the 4C35 is approximately 75 volts and the drop of the 5C22 is about 110 volts. Tube losses are small for the power levels involved.

The hydrogen thyratron replaced the rotary spark gap in the line modulators. This suggests the use of the thyratron in spark gap type of induction heaters. A small 500-watt induction heater using a single thyratron is readily controlled by adjusting the drive frequency for economical induction heaters, diathermy, and electro surgery equipments.

High-speed sweep circuits are another application. Because of rapid deionization, suitably-designed tube circuits may extend the present range of sweep circuits of the thyratron type.

Using a "light modulator" circuit, a hydrogen thyratron has been used to flash a gas discharge tube at frequencies between 5000 and 6000 times per second for high-speed photography. Intense short-duration light flashes obtained in this way can be utilized for stroboscopic study of high-speed mechanisms.

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GAUSS meter

The Only Instrument That Gives DIRECT MEASUREMENT OF MAGNETIC FLUX

Here is a new miniature magnetometer designed for ready measurement of the density and direction of flux in permanent magnets and d-c electromagnets—suitable for laboratory and shop use, for research and development, or production-testing of magnets.

Applications in which the gauss meter has been found useful are: checking flux density and distribution in electric-instrument magnets; checking flux density in arc blowout chutes, in contactor blowouts, and in voltage regulators; studying flux patterns about irregular-shaped magnets.

LIGHTWEIGHT—EXTREMELY EASY TO USE—INEXPENSIVE

This compact instrument can be held in one hand; for flux measurement there is probably no easier instrument to handle and operate. Its tiny prod, with a small area of sensitivity, enables the flux to be measured at what amounts to a single point in the air gap or iron structure—making possible a detailed analysis of flux distribution in any magnetic system. Since it does not depend upon voltages induced in a movable search coil, it is easier to use than the ballistic-type fluxmeter and permits more thorough investigation of magnetic structures. Write for leaflet GEA-4545. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

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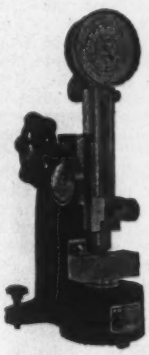

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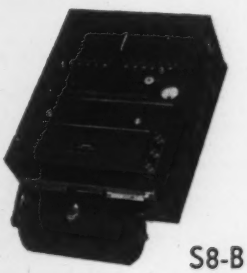

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Instrument Societies

AKRON

The Akron Instrument Society held its regular meeting at the Akron YWCA, March 8th, 1946. The speaker was Mr. Otto Leone, Pittsburgh District Manager for the Bristol Company, who spoke on "Humidity Measurement and Control in Steel and Allied Industries. He explained the difficulties encountered in measuring humidity at the high temperatures encountered, and explained, with the help of slides, some of the methods used to obtain humidity readings at points far above 212°F. The discussion following evidenced the interest with which Mr. Leone's talk was received.

In the brief business meeting following, it was decided to have a dinner meeting for the purpose of adopting a Constitution and By-Laws for this Society.

At the dinner meeting, which was held on March 27th, about 80 members and prospective members were present. After an excellent dinner, the Constitution was presented by the committee and adopted with a few changes. This action establishes us a going concern, with 114 members, including twenty who joined at this meeting. Anyone interested in any phase of Instrumentation is invited to become a member. At the request of the Program Committee, a number of subjects for future meetings were asked for and noted, giving us a substantial backlog for interesting meetings for a long time. The Program Committee also announced the dates for the next meetings. It was agreed to hold our meetings between those of the Pittsburgh and Cleveland Societies, so as to enable one speaker to get to three meetings on one trip if desirable.

—FRED APPEL, JR., *Secretary*

ATLANTA

The regular monthly meeting of the Georgia Society for Measurement & Control was held in the Blue Flame Room of The Atlanta Gas Light Company on March 25.

Mr. J. Harvey Seat, of the Fulton Sylphon Co., gave a brief talk on the way and the reason this society was organized, and as Vice President of the G.S.M.C. invited those that did not belong, the opportunity to become a member.

After this talk he presented a moving picture on "The Story of the Bellows." The film illustrated the manufacturing of the "Seamless" all-metal bellows and its applications in the industrial instruments, automobiles, home thermostats and many other uses.

After the moving picture Mr. C. D. Branson and Mr. L. S. Dysart, engineers from the factory and home of the Fulton Sylphon Bellows answered the many questions that were asked.

Twenty-four persons attended this meeting.

—JOHN B. ROBERTS, *Secretary*

DETROIT

At the March meeting of the Detroit Instrument Society, Mr. Volkenant of the Minneapolis-Honeywell Company gave an unusually well-presented and interesting talk on the role of electronic automatic controls in the war program. Illustrating his lecture with actual samples of the devices under discussion, the speaker traced the development of the electron tube from its earliest stages to the present applications; he then described and—in many cases—demonstrated the following instruments: Proximity fuse, automatic pilot, Norden bombsight, automatic icing and engine fire detectors, capacitance type of fuel indicators, automatic airplane landing equipment, cabin temperature controllers, and others. Amongst his "predictions of things to come" were the $25 vest pocket radio, transatlantic planes with 750 passenger capacities, and electronic tubes with practically infinite life.

In the discussion that followed, the speaker stressed the fact that all controls under discussion were designed for "safe failure," and were usually equipped with manual overrides.

—S. KULKA, *Chairman Publicity Com.*

HOUSTON

The Houston Instrument Society, born in December, 1945, had its fourth meeting at the Houston Engineers Club on Monday, 11 March, 1946. W. H. Fortney (Humble Oil Co.) our newly elected President, presided. Other officers, elected at the February meeting were Lyle A. Williams, Vice President (Sinclair Rubber Co.); R. W. Fritzsche, Secretary, (Fischer & Porter Co.); J. L. Henderson, Treasurer, (Champion Paper & Fibre Co.); R. E. Hansen, Chairman, Program Committee (Leeds & Northrup Co.); M. G. Anderson, Chairman, Membership Committee (Carbide & Carbon Chemicals Co.) and C. L. Shultz, Chairman, Constitution Committee (Shell Oil Co.).

The new officers were afforded enthusiastic support by the attendance of sixty members and their guests, and the steady growth of the society took a jump with the enlistment of fourteen new members making a total of seventy-four.

A change was made in the Constitution to permit the adoption of by-laws at regular meetings without written advance notice, and committee reports emphasized the teamwork that fosters the rapid growth of our new organization. We appreciate the prompt cooperation of each instrument manufacturer with whom we have corresponded, in offering a speaker to contribute to the technical benefits of our Society. W. H. Fortney proposed a long term preparation of instrumentation standards and reference data which will be compiled in loose-leaf form with each member contributing.

We are grateful to Mr. Harry G. Smith, General Sales Manager, Smith Meter Company, for making a special flight from Los Angeles to present interesting and instructive facts dealing with the construction, as well as the practical application, of displacement type meters. Mr. Smith's talk included an eighteen minute Kodachrome movie which appropriately illustrated his remarks. He also displayed a new servomechanism devoloped by his company and discussed its application to problems involving fluids handling. A lively question and answer session ensued.

—R. W. FRITZSCHE, *Secretary*

INDIANAPOLIS

The regular monthly meeting of the Indianapolis Technical Instrument Society was held March 5, 1946, at Purdue University Center, 902 N. Meridian Street. A very interesting talk was given by Mr. P. A. Elfers, of the Fisher Governor Company, on "Control Valves and Diaphragms." Mr. Elfers discussed the construction and characteristics of several types of valves and control diaphragms and illustrated his talk with both slides and actual samples.

Seventy members and guests were present for this meeting.

—MORRIS UNDERWOOD, *Sec'y-Treas.*

KANSAS CITY, MISSOURI

At our March 26 meeting it was announced that we, the Kansas City Industrial Instrumentation Society were accepted into the Technical Societies Council of Kansas City Area.

Mr. Reichow of Minneapolis-Honeywell, and O. L. Boutros enjoyed the complete interest of the excellent turnout. Mr. Zumbell of the Forslund Pump and Machinery Co. presented the Fulton Sylphon Film.

—OLIVER L. BOUTROS, *Sec'y-Treas.*

LOS ANGELES

The March meeting of the California Chapter of the Instrument Society of America was held Tuesday evening, March 5, 1945, at Eaton's Ardmore Cafe. Forty-four attended the dinner with fifty-five at the meeting.

Following a brief business meeting during which our past-president William Warren was elected as our member of the Board of Directors of the national organization, a very interesting talk was given by Thomas Warren, President of Ultra Violet Products, Inc.

The talk was on the subject of "Ultraviolet Radiation." Mr. Warren discussed the commercial methods of generating ultraviolet light and its application to various industrial work, including mining, the oil industry, food processing, chemical industry, criminology and various other uses.

Several types of ultraviolet lamps were demonstrated and some of the effects on ore bodies, textiles, invisible inks, etc., were shown.

—M. D. PUGH, *Secretary*

NEW JERSEY

For the April meeting of the New Jersey Section Mr. V. L. Parsegian of the C. J. Tagliabue Div., Portable Products Co., enlightened us on "Thermocouple Methods of Temperature Measurements" and as director of research for his company one might have expected a long-haired discussion in the formal manner. At the start, however, Mr. Parsegian dispelled any such thoughts in the minds of our record-breaking audience of 112 members and guests. His talk was strictly informal and since he invited questions from the floor he got 'em, fast and furious. While he took us back to fundamentals he considered principles from the standpoint of the man in the field, and where the field men didn't agree they soon said so. Mr. Parsegian humorously enlightened on what was "bad" and what was "good" practice in the application of thermocouples.

President Roberts announced at the end of the discussion that he had the names of 99 paid-up members to take with him to the National meeting in Detroit. By locking the doors we succeeded in shaking down one more man for his dues, to round out the number to an even hundred.

—H. S. CLOSE, *Secretary*

NEW YORK

The March 1946 meeting of the Instrument Society of America, New York Section, held at the Men's Faculty Club, Columbia University, opened with a dinner at 6:45 P. M. Seventy-three members and guests were present for the meal, with an additional twenty coming later for the meeting.

Prof. C. F. Kayan called the meeting to order at eight o'clock and after reading of

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Instruments comes out on the 15th and it may be after the 20th when it reaches all readers. Calendar items must be in our office before the first of the month.

If, for example, you want to announce an event to be held between June 1 and June 20, don't plan to have it inserted in the June issue: it must go in the MAY issue; and your announcement must be on our desk before May 1st.

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M. F. Behar, Editor

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Other features include (1) the special gage, with a wide bourdon tube that develops 3 or 4 times the usual pointer torque; (2) a release which opens at 1 or 2" H_2O above the regulated pressure; (3) a 3-way by-pass for switch-over from an automatic control instrument.

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minutes, reports from committee chairmen and introduction of guests, the speaker of the evening, Charles H. Colvin, was introduced.

Mr. Colvin's paper was entitled, "What Price Instrument Research?" He presented the subject clearly and concisely, reducing it to a typical pattern of twenty-two steps: from No. 1, Recognition of the Problem by Customer, Sales or Research Groups, to step No. 22, Approval of Revised Specifications. Each step followed in an orderly and necessary sequence. The necessity for, as well as, the time and expense involved in each step were clearly explained. Examples were given to illustrate various points.

Discussions following the talk consisted of examples and illustrations by members and guests who were representatives of research, sales and management groups.

After a rising vote of thanks to Mr. Colvin for such an interesting evening, the meeting was adjourned by 10:00 P. M.

—CHARLES DANA COREY, *Secretary*

NORTHERN INDIANA

The Northern Indiana Section of the Instrument Society of America held its March meeting on Friday the 15th at the Lake Hotel in Gary.

The speaker for the evening, Mr. Theodore Cohen of the Taco Engineering Co., gave an enlightening talk on "Electronics."

Mr. Cohen explained in a very able manner many uses of the Vacuum tube and illustrated his descriptions with blackboard sketches. The electronic voltmeter, wattmeter, Wheatstone bridge, as well as methods of controlling liquid level, flow and temperature by means of electronic devices were among the items portrayed by the speaker.

Mr. Cohen asserted that although great strides have been made in the development and use of electronics in industry, the surface has actually just been scratched and the possibilities for the future are unlimited.

—PAUL KEEFER, *Member Publicity Com.*

PHILADELPHIA

With an attendance of 110, the March meeting of the Philadelphia Section began with an announcement of its two I. S. A. Regional Conference delegates, M. H. White of Atlantic Refining Company, and E. J. Grace of Sun Oil Company.

Mr. Harold Vogt, a Corning Glass Physicist, gave the featured lecture demonstration on "Modern Glasses and Their Application." The speaker had an impressive background of many years of highly technical research in glass, X-ray, and radium work, including an association with Professor K. T. Bainbridge in atom smashing developments.

Mr. Vogt after mentioning that there are 50,000 glass recipes, classified them into five main types: Silica, high silica, boro silica, lead, and lime glasses. He discussed each type with regard to its mechanical, electrical, and optical properties, and general applications.

Throughout the talk Mr. Vogt illustrated many of his points with rather startling demonstrations using some of the huge array of glass equipment he had on display. Frying ice on a glass stove grille, dropping glass dinnerware seven feet on a hardwood plank, driving a large nail through a wooden plank with a two-inch diameter precision glass piston, setting a newspaper on fire with an infrared filter and light source were some of the effective means used to show the heat shock resistance, toughness, and filtering properties of various glasses.

Newly developed ultraviolet-passing "germicidal" glass, foam glass, the mass production of optical glass, glass cloth using 0.00005 inch diameter fibers (four times finer than previous fiber diameters), metallic surfacing on glass, capable of being soldered, and a glass fiber sheet impregnated with plastic which has the highest strength to weight ratio of any known material, were some of the high interest items. A lively discussion followed the address.

—J. J. FREGEAU,
Chairman, Publicity Committee

PITTSBURGH

The monthly meeting of the Pittsburgh Chapter of the I. S. A. was held at the Roosevelt Hotel on March 25, 1946. The dinner which preceded the meeting proper was attended by forty-nine members and guests of the chapter.

Paul Exline, President of Pittsburgh Chapter, introduced Al Sperry, President of the national organization. Al spoke briefly on the progress of the Society to date and also touched on the ambitions and dreams to be fulfilled sometime in the future.

Chairman Jacobs of the Membership Committee reported that seven new members were accepted in the Pittsburgh Chapter during the past month. Those attending the meeting were given rounds of welcoming applause.

The speaker of the evening, Mr. M. H. White of Atlantic Refining Co., was introduced by President Exline. An audience of approximately seventy-five listened to a most interesting and informing talk on "Instrument Maintenance in an Oil Refinery." Mr. White described the methods used at the Philadelphia Refinery of the Atlantic Refining Co. to assure most efficient operation of the numerous types of instruments used to indicate, record and control the various quantities encountered in a large refinery. Suitable slides were shown to aid in driving home the idea that a well organized instrument maintaining group was a good investment when the number of instruments warranted such an organization.

—T. D. FULTON, *Member Meetings Com.*

SAINT LOUIS

The Saint Louis Section of The Instrument Society of America held its regular February meeting on February 25 at the York Hotel. Chairman Boyle read a letter from National Secretary Rimbach requesting reservations for the regional meeting to be held in Detroit, on April 4th and 5th.

The program consisted of three talks by members of the section, Mr. Gus Holubeck of the Union Electric Co., Mr. Paul Hoyt of Shell Oil Co., and Mr. V. H. Hiermeier of Brown Instrument Co. Mr. Holubeck explained the method of measuring the fly-ash content in gases passing from boilers to electrostatic precipitators, and from the precipitators to the stack, thus measuring the efficiency of the removal of fly-ash and also the amount discharged to the atmosphere.

Mr. Paul Hoyt discussed liquid level control, explaining the advantages and disadvantages of the different types, and experience with each as used in oil refineries. It was emphasized that each type has its application, and that proper installation is all-important in the proper operation.

Mr. V. H. Hiermeier discussed some properties of thermocouples. The alloys must be 100% correct—the wire should not be abused—it must not be stretched or twisted. About 95% of the thermocouples in the average plant need to be questioned as to accuracy (3 or 4 degrees or more) and the error can be either up or down. Compensating lead wire is of no value if it is connected to an instrument that has no provision for compensating for temperature changes.

Following the talks and questions, films were shown (sound) describing the construction and maintenance of the Electronic Regulator for Aircraft Superchargers, as used on many U. S. planes during the war. Mr. Zephyrin Marsh of the Minneapolis-Honeywell Regulator Co., who was an instructor in the European Theater on this subject, presented further explanations. The films shown were Army Training material.

Attendance approximated 50 members and guests, who found the meeting of great interest.

—H. E. ZEFFREN, *Sec'y.*

The St. Louis Section I. S. A. held its regular meeting on Monday, March 25, at the York Hotel in St. Louis. Chairman Boyle announced the nominations for the executive committee. Mr. H. Freeman, of the Program Committee, discussed plans for the May meeting, which will be a Smoker and Entertainment, and Manufacturer's Representative's Night.

The speaker of the evening was Mr. Paul Wing of the Mason-Neilan Co., who discussed Control Valve Characteristics. Mr. Wing discussed the effect of line drop on control valve operation, and stated that 33% of the drop should appear across the valve at full opening, with more drop desirable in some instances. Valve were stated to have about a 50 to 1 flow range, as complete shut-off is not usually obtainable. The advantages of the equal-percentage valve over the linear type of valve were emphasized. Mr. Wing stated that in the cases where valves are oversize, the linear valve gets into serious trouble while the equal-percentage valve is able to control within satisfactory limits and with minimum change of setting of the controller. The speaker presented considerable data and curves to substantiate his contentions.

Sixty members and guests were present at this meeting.

—H. E. ZEFFREN, Sec'y.

TENNESSEE

The Tennessee Section of the I. S. A. held its regular monthly meeting at the Kingsport Inn, February 13th.

Mr. J. F. Sneath, of Leeds and Northrup Company, addressed us on "What is pH, and How to Use it." He illustrated and described pH, pointed out its industrial applications, told of the developments of both reference and measuring electrodes, describing the different types, and gave their principles of operation. The smallest amount of theory possible was used, and everyone seemed to think he did a wonderful job of a tough assignment. We all hope to have Mr. Sneath back for another talk soon.

—CHARLIE F. PALMER, *Secretary*

WASHINGTON

The twentieth meeting of the Washington Section, I. S. A. was held at the Department of the Interior Auditorium, March 19, 1946.

In line with the subject, the speakers were introduced with a few brief comments on the history and background of methods for automatic transmission of meteorological information by Dr. A. H. Mears, Councilor of the Section and Mechanical Engineer, Instrument Division, U. S. Weather Bureau.

The first speaker was Mr. Vernon D. Hauck, Chief Engineer, Friez Instrument Division, Bendix Aviation Corp. The subject, "Radiosondes: Present Status of the Art," covered the principles and problems of upper-air weather observations and a thorough description of the audio-modulated radiosonde and the receiving and recording equipment manufactured by Friez.

The second speaker, Mr. Louvan E. Wood, Engineer, Friez Instrument Division, elaborated on the principles of the radiosonde with an explanation and description of the Automatic Weather Station manufactured by Freiz, which is an elaborate but direct counterpart of the radiosonde for use in obtaining regular surface weather observations from uninhabited regions.

The talks were well illustrated by slides and supplemented by a display of radiosondes, pressure, temperature and humidity elements.

Considerable interest in the subject was demonstrated by an active discussion period and an attendance of 135.

—ROBERT G. QUICK, *Recording Secretary*

WYANDOTTE

At the March 25 meeting of the Instrument Society of Wayne County, Mr. Lester Demler of Wallace and Tiernan gave us a very interesting talk mostly on aneroid instruments. There were slides showing the general construction and the adaptations for use as barometers and altimeters and for accurate measuring of low pressures; also several showing a vacuum regulator for instrument testing and a mercurial instrument capable of being used either as a barometer or manometer.

After the meeting we did some promoting and ticket-selling for the I. S. A. convention.

—JOHN MACPHERSON, *Vice President*

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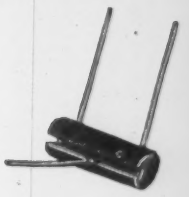

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INSTRUMENT SOCIETIES CALENDAR

City, Society, and Secretary	Date and Place	Subject
Akron, Ohio; The Akron Instrument Society; Fred Appel, Jr., 932 Columbia Court, Barberton, Ohio.	**April 23,** Y. W. C. A.	"Control Valve Characteristics," R. Rockwell, Mason-Neilan Reg. Co.
	May 28	To be announced
Atlanta, Ga.; Georgia Society for Measurement and Control; John Roberts, 439 Deering Rd.	**Apr. 29**(A), Blue Flame Room, Atlanta Gas Light Co.	"The Principle of the ElectroniK Instrument," David W. Choate, Brown Instrument Division
Baltimore, Md.; Baltimore Section, I.S.A., F. Ragan, Fuel Div., Beth. Steel, Sparrows Pt., Md.		
Charleston, W. Va.; Charleston Section, I.S.A.; M. B. Lorig, 1506 Virginia St., Charleston 1	**May 6**(B), Ruffner Hotel	"Pneumatic Transmission and Control," W. B. Heinz, Cochrane Corp.
Chicago, Ill.; Chicago Section, I.S.A.; A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago	**May 6**(B), To be announced	"New Electronic Measuring Instruments," H. C. Rowe, Rowe Radio Res. Lab.
Cleveland, Ohio; Cleveland Section, I.S.A.; A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3		
Cumberland, Md.; Cumberland Section, I.S.A.; Carl Lower, LaVale Rt. 1, Cumberland, Md.	**Apr. 23**(B), Queen City Hotel	"Centralized Instrument Control, Calibration and Maintenance," William Bowman, Gulf Research & Development Co.
	May 28(B), Same	"Diaphragm Control Valves," Bruce Irwin, Hammel-Dahl Company
	June 25(B), Same	"Representing Instrument and Control Manufacturers Precautions in Instrument Installations," Miflin Jacobs
Detroit, Mich.; Detroit Section, I.S.A.; J. D. McCullough, Horace H. Rackham Bldg., 100 Farnsworth, Detroit 2	**Apr. 17**(D), Ethyl Research Lab.	"Manometer Applications in Industry," A. A. Hejduk, Meriam Instrument Co.
Ft. Worth, Tex.; Ft. Worth Electronics Club; W. H. Farrington		
Gulf Coast (Tex.); Gulf Coast Section, I.S.A.; O. D. Sanders, Neches Butane Co., Port Neches, Texas	**Apr. 16,** Lamar College	"The Smith Meter," J. W. Harris, Smith Meter Co.
Hartford, Conn.; Hartford Society for Measurement & Control; Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.	**Apr. 16**(B), Bond Hotel	"Comparison of Materials for Gages," H. O. Richter, W. R. Moore, Norton Co.
	May 21(B), Same	Annual Business Meeting
Houston, Tex.; Houston Instrument Society; R. W. Fritsche, 630 A M & M Bldg., Houston 2		
Indianapolis, Ind.; Indianapolis Technical Instrument Society; Morris Underwood, Indianapolis Power & Light Co., Indianapolis 6	**May 7,** Purdue Univ. Center	"Basis Theory of B-Carbon-Pile Type of Voltage Regulator," F. T. Rodgers, Jr., U. S. Naval Ordnance Plant
	June 4, Same	(Subject to be announced). D. O. Komich, Trimount Instrument Company
Kalamazoo, Mich; Kalamazoo-Battle Creek Section, I.S.A.; F. R. Brydges, 223 Chestnut St., Battle Creek.	**May 8**	"Electronic Devices," Glenn Miller, Kellogg Co.
Kansas City, Mo.; Kansas City Section, I.S.A.; O. L. Boutros, 1627 E. 31st St., Kansas City 3	**Apr. 30**(A), Kansas City Univ.	"Trends on Instrumentation for Natural Gas Industry," P. Miller, Panhandle Eastern Pipeline Co.
Los Angeles, Calif.; California Section, I.S.A.; M. D. Pugh, 35 S. Raymond Ave., Pasadena 1	**May 7**(B), Eaton's Ardmore Cafe	To be announced
	June 4(B), Same	To be announced
Newark N. J.; New Jersey Section, I.S.A.; H. S. Close, 831 Dixie La., Plainfield, N. J.	**May 7**(B), Essex House	"Selling an Instrument Department to Management," M. H. White, Atlantic Refining Co.
	June 4(B), Bayway Refinery, Std. Oil of N. J.	"Inspection and Review of Full Scale Aviation Fuel Testing Facilities," G. A. Martin, O. G. Lewis, Std. Oil Dev. Co.
New Orleans, La.; New Orleans Section, I.S.A.; W. H. Haney, 1016 Esplanade Ave., New Orleans		
New York, N. Y.; New York Section, I.S.A.; C. D. Corey, Rieber Research Lab., 127 E. 73rd Street, New York 21	**Apr. 22**(B), Men's Faculty Club	"Development of the Stroboscope," I. G. Easton
N. Indiana; North Indiana Section, I.S.A.; C. P. Haynes, Red River Oil Ref., 935 177th Pl., Hammond, Ind.	**Apr. 17**(B), Lake Hotel, Gary	"Colorado Narrow-gage Railways," Richard Potts
	May 15(B), Same	"L & N Electronic Potentiometer," L. H. Coleman, Leeds & Northrup Co.
Philadelphia, Pa.; Philadelphia Section, I.S.A.; Clarence W. Wood, Mason-Neilan, 6908 Market St., Upper Darby, Pa.	**April 17**(B), Broadwood Hotel	"Instruments in the Steel Mill," Henry S. Hall, Lukens Steel Co.
	May 15(B), Same	"Instrumentation in the Production of Fermentation Ethyl Alcohol," Daniel N. Kohn, Consulting Chemical Engineer
Pittsburgh, Pa.; Pittsburgh Section, I.S.A.; L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	**Apr. 22**(B), Roosevelt Hotel	"Control Valve Characteristics," R. Rockwell, Mason-Neilan
	May 27(B), Same	"Fractional H-p. Motors," C. G. Veinott, Westinghouse
St Louis, Mo: Saint Louis Section, I.S.A.; H. E. Zeffren, 5625 Enright Blvd., St. Louis 12	**Apr. 29**(C), York Hotel	"New Developments in Manometers," A. A. Hejduk, Meriam Instr. Co.
	May 27(C), Same	"Manufacturers' Representatives Night," Smoker and Entertainment, No Speaker
Sarnia, Ont., Canada; Sarnia Instrument Association; K. Williamson, 168 Cobden St., Sarnia		
Southwest Texas; South Texas Instrument Society; Homer C. Givens, LaGloria Corp., Falfurrias, Tex.		
Kingsport, Tenn.; Tennessee Section, I.S.A.; C. F. Palmer, 2924 J. C. Hwy., Kingsport		
Toronto, Ont., Canada; Ontario Section, I.S.A.; T. C. Agnew, Minneapolis-Honeywell	**Apr. 18**(B), Chez Paree Rest.	"Instrumentation in Glass Industry," W. O. Fleming, Corning Glass (Canada)
Washington, D. C.; Washington Section, I.S.A.; G. M. Rolls, c/o American Instrument Co., 8010-8020 Georgia Ave., Silver Springs, Md.	**Apr. 24**(D), Interior Dept. Auditorium	"What Price Instrument Research?" Chas. H. Colvin
Whiting, Ind.; Whiting Instrument Men's Guild; Fred T. Lucas, 1713 Myrtle Ave., Whiting, Ind.		
Wyandotte, Mich.; Wayne County Section, I.S.A.; Chas. Chessrown, P. O. Box 150, Wyandotte	**Apr. 22**(B), Presbyterian Church, Wyandotte	"Automatic Control Applied to Batch Processes," George Love, Taylor Instrument Cos.

(A)Meeting at 7:30, no dinner (B)Dinner at 6:30, meeting at 8 (C)Dinner at 7, meeting at 8 (D)Meeting at 8, no dinner (E)Dinner at 6:30, meeting at 7:30

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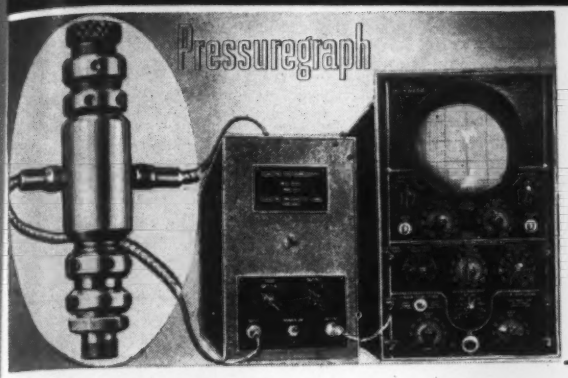

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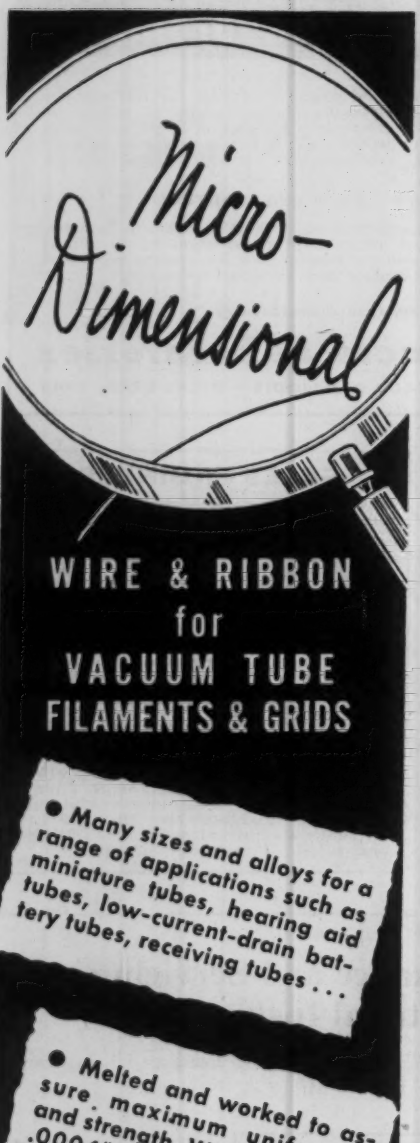
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Manufacturers' New Literature

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N-106 **Motor-driven Controls,** 4-page 8½" × 11" Bulletin 71 illustrates and describes a wide variety of motor-driven controls including brush and drum type, silver contact type, mercury contact type and thermatic type. These are used for pre-determined timing, time delay, synchronizing, automatic starting and stopping, reversing actions, sequence operations, automatic and repeat cycles, signaling and keying. Interlocks can be furnished. Reynolds Electric Company, 2650 W. Congress Street, Chicago, Ill.

N-107 **Vibration Table.** Single-page 8½" × 11" bulletin describes and pictures the RV3 vibration table, designed to shake out faults in assemblies and components, thus expediting correction and avoiding time consuming field tests. Amplitude and direction of vibration are adjustable. L. A. B. Corporation, Summit, New Jersey.

N-108 **Electronic Switch.** 2-page 8½" × 11" bulletin pictures, describes and gives specification and applications of Type YE-9 switch designed for special electrical studies of wave-form, phase, frequency relationship, and for the comparison of amplitude. It will show the simultaneous observation, for comparison, of two or more independent signals on the screen of a single cathodetube oscilloscope. Mechanical vibrations, sound, light, and other magnitudes convertible into electrical functions may be compared. General Electric Company, Electronics Department, Syracuse, N. Y.

N-109 **Sealed Electrical Components.** 4-page 8½" × 11" bulletin illustrates and describes the "Hermeti Can" for hermetically sealing transformers, relays, condensers, rectifiers and switches against atmospheric action. A number of sizes and shapes are pictured and any number of terminals, from one to nine or combinations thereof, may be supplied in hollow-tube or flattened-and-pierced styles. Cincinnati Electric Products Company, Cincinnati 12, Ohio.

N-110 **Radiation Pyrometer.** 6-page 8½" × 11" folder pictures and describes instrument for checking temperatures in all cases where the application of heat is necessary for producing or for treatment of products. It is specially constructed for intermittent or occasional readings and may be used for checking permanently-installed instruments. The Pyrometer Instrument Co., 103-105 Lafayette Street, New York, N. Y.

N-111 **"Apparatus Headliners."** 4-page 8½" × 11" issue of this house organ features laboratory hot-plates with stepless control. Also illustrated and described are various types of laboratory tongs, an improved model laboratory timer, a double-scale pH electrometer, spectrophotometer, electronic photofluorometer and the new "Liquijector" for removing moisture and dirt from compressed air lines. Boder Scientific Company, 907-909 Penn Avenue, Pittsburgh 22, Pa.

N-112 **Thread Gages.** 26-page 6" × 9" booklet covers the maker's complete line of plug and ring gages made in tool steel alloys and in Stellite: working thread plug gages, setting thread plug gages, thread ring gages, thread plug gages, Army and Navy aeronautical taper pipe thread plug gages and concentricity gages. Particular attention is given to the "Pla-Chek," a new high-precision instrument for surface-plate checking work. Cadillac Gage Company, 20316 Hoover Road, Detroit 5, Michigan.

N-113 **Temperature Control System,** 8-page 8½" × 11" bulletin describes and pictures the "Econostat," designed to regulate the heating system of a building directly from the outdoor temperature by varying "heat on" periods in accordance without outdoor temperature changes. A chart illustrates the operation of the instrument controlling a motor-operating zone valve on the main supplying district steam to the direct radiators of a two-story commercial building. Barber-Colman Co., Rockford, Illinois.

N-114 **Industrial Thermometers.** 16-page 6" × 9" folder pictures and describes maker's line of industrial thermometers and gages. Shown are thermometers with extension neck sockets, long-stem sockets, separable sockets; recording thermometer with electric alarm mechanism; dial indicating thermometer; wet and dry bulb hygrometer; U gages for measuring draft, vacuum and low gas and air pressures; mercury column vacuum gage; and absolute pressure gage. Moeller Instrument Co., 132nd St. and 89th Ave., Richmond Hill 18, New York, N. Y.

N-115 **"Velometer."** 8-page 8½" × 11" Bulletin 2448-F illustrates and describes instantaneous direct-reading air velocity meter for heating, ventilating and air-conditioning work in design and installation stages and in maintaing efficient operation later. Also shown and described are numerous application accessories. A number of illustrations show typical uses. Illinois Testing Laboratories, Inc., 420 North LaSalle St., Chicago 10, Ill.

N-116 **Beam-Splitting Pellicles.** 4-page 8½" × 11" bulletin describes and illustrates the action of tough, elastic membranes available in 0.0002" to 0.001" thicknesses. Thickness is uniform to a few wavelengths of light. The pellicle mirror is free of striations and ghost images, and refractive errors are eliminated. Some applications are described. **National** Photocolor Corp., 305 East 43rd St., New York 17, N. Y.

N-117 **Bridge Test Sets.** 4-page 8½" × 11" Bulletin B 100 describes and illustrates a light-weight Wheatstone bridge for laboratory, production or communication testing, featuring single-dial selection of all ratios, and positive-contact self-wiping switches. Briefly described and pictured are maker's galvanometers and megohmmeters. The Winslow Co., 1-9 Liberty St., Newark 5, N. J.

N-118 **Laboratory Panels and Associated Equipment.** 36-page 8½" × 11" Booklet No. 142 suggests recommendations for use of panels and associated equipment. Section One of booklet gives general information covering manufacturer's various items; Section Two covers

equipment for physics, chemistry, general science and electric shops in schools; Section Three covers equipment for colleges and universities. All sections contain numerous illustrations of equipment and installed panels. The Standard Electric Time Co., Springfield, Mass.

N-119 **Bryden Rod Clamps.** 4-page 3" × 6" bulletin describes and pictures various types of non-rust non-slip rod clamps made of aluminum and equipped with stainless steel socket screws, designed for research workers, chemists, tool makers and control laboratories of industrial plants. Chandler and Stedman, 170 Parmenter Road, West Newton, Mass.

N-120 **"General Radio Experimenter."** 8-page 6" × 9", Vol. 20, No. 8 of this house organ contains the following articles: (1) "The Series and Parallel Components of Impedance;" (2) "Heat Dissipation from Cabinets;" (3) An Engineering Approach to Trout Fishing." General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

N-121 **Pneumatic Telemetering.** 28-page 8½" × 11" Data Book No. 1000 contains a comprehensive and profusely-illustrated presentation of the pneumatic force-balance principle and its use in industrial measuring instruments. Construction and operation of various types of pneumatic transmitters are described and illustrated. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

N-122 **Sound Pressure Measurement Standard.** 4-page 8½" × 11" bulletin describes a precision acoustic instrument developed for making absolute sound pressure measurements throughout the audio range without appreciably disturbing the sound field. Some of the applications listed are: absolute free field sound pressure measurements; sound pressure measurements inside small enclosures, horns, conduits, and acoustic filters; determination of wavefront along horns, etc.; pilot microphone for maintaining or controlling intensity level of a sound field, blast wave analysis from explosions and gunfire; reference standard for calibrating other microphones; contact microphone for vibrations in solids; and calibration of headphones with artificial ear couplers. Massa Laboratories, Inc., 3868 Carnegie Ave., Cleveland 15, Ohio.

N-123 **Vhf.-Uhf. Wattmeter.** 2-page 8½" × 11" bulletin illustrates and describes instrument for transmitter power output measurements, within the ranges 1 to 500 watts and 10 to 1500 megacycles. This 50-ohm instrument is especially suited to equipment having 50-ohm coaxial output terminals. Complete data are given on application, impedance, thermocouples, calibration and accessories. Bird Electronic Corp., 1800 East 38th St., Cleveland 14, Ohio.

N-124 **Rotameters.** 8-page 8½" × 11" bulletin profusely illustrated contains an easily understood explanation of rotameter advantages and covers the most prominent styles. Included are details of the "Master Enclosed Rotameter" for normal pressure and temperatures; the "Armored Rotameter" for high pressures and temperatures; meters for recording, controlling and totalizing rates of flow; meters for very low flows and those for extremely large flows; laboratory rotameters and others. Also contains two pages of engineering recommendations on measuring flow rates of difficult and corrosive fluids. Fischer & Porter Co., Hatboro, Pa.

N-125 **Switchboard Assemblies.** 8-page 8½" × 11" bulletin pictures and describes maker's line of switchboard instruments said to be complete in respect to function, range, type and case style. The standard line includes d-c. ammeters and voltmeters; a-c. ammeters, voltmeters, wattmeters, frequency meters, synchroscopes and power factor meters. Re-

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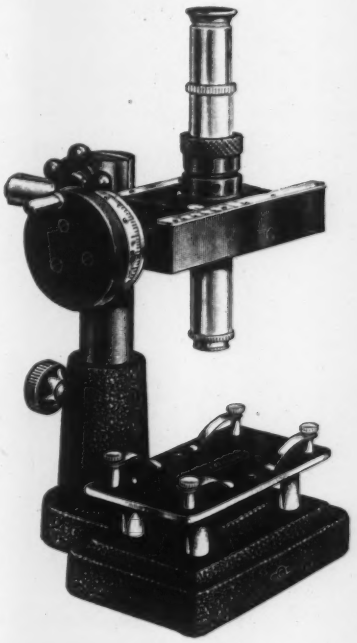

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